FULL COLOUR THINKING

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Simulation-Based Valuation of Project Finance Investments in sub-Saharan Africa and its Effects on Net Present Value and Default Probabilities

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by

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ABSTRACT

This paper addresses the issue surrounding the valuation of valuing large-scale infrastructure projects located in emerging and frontier market countries. These are economies which, traditionally, have been characterised as having high levels of risk and uncertainty, thus presenting a significant challenge to capital allocation decisions and the associated theme of narrowing the finance gap. In light of this, a case study is used to investigate the impact that simulation has on the valuation of an actual infrastructure project located in a sub-Saharan African economy. Specifically, a Monte Carlo simulation-based cash flow model is presented of an investment into a renewable energy project located in South Africa. Results of the simulation process indicate the degree to which certain variables affect the output factors, juxtaposed with an initial base case. A clear need is established for a more sophisticated valuation method in order to accurately judge the investment opportunity and Monte Carlo simulation is presented as a viable solution.

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GLOSSARY OF TERMS

ARCH	Autoregressive Conditional Heteroskedasticity
BCBS	Basel Committee on Banking Supervision
BRIC	Brazil, Russia, India, China
BIS	Bank of International Settlement
CRO	Chief Risk Officer
CSP	Concentrated solar power
DBSA	Development Bank of Southern Africa
DCF	Discounted Cash Flow
DSCR	Debt Service Coverage Ratio
DFI	Development Finance Institutions
EAD	Exposure at Default
EPC	Engineering Procurement and Construction
EWEA	The European Wind Energy Association
IPFA	International Project Finance Association
IRB	Internal Ratings Based
GARCH	Generalised Autoregressive Conditional Heteroskedasticity
GDP	Growth Domestic Product
IMF	International Monetary Fund
IRRS	Internal Risk Rating System
IRR	Internal Rate of Return
JIBAR	Johannesburg Interbank Agreed Rate
LGD	Loss Given Default
M	Maturity of Exposure
MW	Megawatt
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
O&M	Operations and Maintenance
PD	Probability of Default
PPA	Power Purchasing Agreement
PV	Photovoltaic
REIPPPP	Renewable Energy Independent Power Producer Procurement Program
S&P	Standard and Poor’s
SADC	Southern African Development Community

UNEPP	United Nations Environment Protection Programme
US	United States
USD	United Stated Dollar
ZAR	South African Rand

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1. INTRODUCTION

1.1. Research Area

The research concerns itself with the valuation of project finance investments. At present, the body of literature covering the topic extends primarily to its qualitative characteristics. In particular, issues regarding its defining features vis-à-vis corporate finance, as well as its contractual and legal elements have been thoroughly addressed.

In contrast, only a number of papers exist that explicitly address the methods of valuing large-scale infrastructure projects. Underscoring this, no empirical studies have been conducted that exhibit the applicability of simulation techniques in valuing projects in an emerging market setting.

1.2. Problem Statement

A review of the relevant literature (as outlined in more detail in Section 2 below) shows that the valuation of project finance investments is contingent on the accurate estimation of future cash flows. However, there is no agreement on the appropriate technique for forecasting cash flows, with a number of modelling approaches having been put forward.

The intention of this research, therefore, is to analyse the applicability of one of these methods, Monte Carlo simulation, as an improved method for valuing project finance investments, with specific reference to large-scale infrastructure projects located in emerging market environments.

1.3. Purpose and Significance of the Research

This paper addresses the issue surrounding the valuation of large-scale capital projects which are located in emerging and frontier market countries. This is important when considering capital allocation decisions vis-à-vis these regions as well as the broader theme of narrowing the infrastructure finance gap.

In addressing this topic, this paper will contribute to a thus far limited body of literature on appropriate techniques for forecasting future cash flows, with a specific focus on the usefulness of Monte Carlo simulation in project valuation.

1.4. Research Questions and Scope

The topic of project finance is broad. Many of its practising principles overlap with those in other fields, including the general areas of corporate finance as well as risk management and project management.

Acknowledging this, the research will deal exclusively with the appraisal of large-scale infrastructure investments that are backed by way of the project finance approach. Moreover, as it is the intention of this paper to highlight the features that underlie an accurate valuation – thus allowing for the raising of debt capital – the research aspects of valuation will be dealt with exclusively from a financier's perspective.

In further limiting the scope of the research, this paper will look at the valuation outcomes of the various models on a single project finance investment. In particular, these valuations will take place concerning a renewable energy project in South Africa, with the comparative valuations based on two outputs, namely net present value (NPV) and the probability of default (PD). Given this, this paper's research questions are outlined below.

Central Research Question 1:	Does the incorporation of Monte Carlo simulation have an effect on the NPV?
Central Research Question 2:	Does the incorporation of Monte Carlo simulation have an effect on the PD?

It is noted here, that theoretically, Monte Carlo simulation will have an influence on the aforementioned valuation metrics due to the effects of path dependency and non-linearity on the calculated cash flow streams. It is, however, more important for this paper to determine the size of this effect; given that the simulation procedure takes into account a number of identified risk considerations into the cash flow forecast.

In addition, it is an objective of this paper to determine which elements of the simulation procedure are crucial for obtaining stable results. This concerns itself with the correct parameterisation of the valuation model; specifically, what the appropriate cash flow distribution frequency is. The sub-research question has, therefore, been developed as follows:

Sub-Research Question 1: Will a shorter interval of cash flow have an effect on the probability distribution of the NPV?

This paper will address the aforementioned research questions in the following format: Section 2 reviews the existing literature on project finance, generally and the valuation techniques employed in valuing large-scale infrastructure projects, specifically. Section 3 covers the methodological framework used to test the research question and the associated limitations to the inferences drawn from the simulation results. In Section 4, both the case study and the project finance valuation model used to test the research question are presented. In Section 5, the simulation results are reported and interpreted. The paper is finalised with a conclusion and recommendations for future research in Section 7 and 8, respectively.

2. LITERATURE REVIEW

In providing a basis for this paper, the literature review shall be presented along three pillars. Sub-section one will provide a brief overview of the history of project finance; starting from its historical application, through to its modern form – where it was first employed as a viable financing tool in the United States (US) in the 1930s and has since seen increased use and relevance in Emerging and Frontier Markets[1]. Linked to this, an overview of the sub-Saharan Africa-specific challenges vis-à-vis meeting infrastructure development requirements and bridging the accompanying finance gap is explored in sub-section two.

The prelude offered by sub-sections one and two is important, as it introduces the risks associated with project finance investments in these markets through the concept of project 'bankability' – a term used to refer to the technical and economic soundness of the project (European Investment Bank, 2010).

According to Smith (2010), a bankable project must satisfy the criteria of bankability which consists of two important factors. Firstly, the project has to generate sufficient cash flow to cover the debt service payments as they become due. The second factor is the structural risks that a project must overcome; these being unique to the host country in which the project is located and include: environmental risks, regulatory environment, and political risks. Indeed, these risk factors are assumed to be higher, or more uncertain, in developing countries (Hoffman, 2001) (Smith, 2010).

Given that project finance is predicated on the precise estimation of future cash flows, it becomes clear that the project finance investing is inherently more challenging in developing countries; particularly as the associated risks and uncertainties in these markets affect cash flow estimation.

While the theoretical aspects covering large-scale capital investment appraisal are introduced in sub-section three of the literature, the quantification of these elements are investigated in the financial modelling section of this paper (Section 4) – where the benefits of a stochastic cash

[1] "Emerging Markets" and "Frontier Markets," which is used synonymously with "Emerging Economics and "Frontier Economies," respectively, refers to economies and markets in developing or industrialising regions of the world. For the purposes of this paper, it is used to denote developing regions of the world.

flow modelling approach to valuation of a project located in a developing country is demonstrated.

2.1. The Project Finance Market

As stated in the introduction to this theoretical section of the paper, the key component of project finance is the accurate estimation of future cash flows. This dependence is apparent when the numerous definitions put forward in academic literature are analysed. [2]

Yescombe (2002) defines project finance as: "a method of raising long-term debt financing for major projects through "financial engineering", based on lending against the cash flows generated by the project alone; it depends on a detailed evaluation of a project's construction, operating and revenue risks and their allocation between investors, lenders and other parties through contractual and other arrangements." [3]

Finnerty (1996) also stresses the importance of cash flow forecasting through his definition put forward, stating: "Project Finance is the raising of funds on a limited-recourse or non-recourse basis to finance an economically separable capital investment project in which the providers of the funds look primarily to the cash flow from the project as the source of funds to service their loans and provide the return of and a return on their equity invested in the project." [4]

Finally, the definition adopted by the International Project Finance Association (IPFA) (2015) – a non-governmental industry body promoting project finance transactions is markedly similar. Project finance is seen as: "the financing of long-term infrastructure or industrial projects and public services based on a non-recourse or limited recourse financial structure, where debt and equity are used to fund the establishment and paid back from the cash flows generated by the project."

Dating back to 1299, the earliest economic equivalent of the financing technique relied heavily on this principle: a merchant bank entered into a non-recourse loan transaction with the English Crown to fund the operating costs of a mineral extraction project. In exchange, the bank received a lease for the mine and a mining concession – entitling the bank to the entire amount

[2] While no universally adopted definition of Project Finance exists, this paper adopts the definition as put forward by Finnerty (1996)
[3] Yescombe p. 1.
[4] Finnerty (1996), p. 1.

of mineral ore they could extract over a one year period (Commer, 1996) (Finnerty, 1996) (Gardner & Wright, 2010) (Esty, Chavich, & Sesia, 2014). Using modern project finance terminology, the loan financing was secured by the accurate estimation of the project's output, or assets.

Termed 'production payment financing' in today's financial parlance, the use of these structured finance techniques would become popular in the financing of oil exploration and extraction projects in the US during the 1930s (Esty, Chavich, & Sesia, 2014). Specifically, oil and gas explorers would finance oil field exploration in Texas, where the proceeds from oil sales – as was determined through the estimation of reserves – were allocated to repayment of the loan (Esty, Chavich, & Sesia, 2014).

A number of variations of the production payment loan structure developed, but it was not until the development of the North Sea oil fields in the 1970s that the financing method is said to have assumed its modern form by adopting some of the characteristics it has today (Kleimeier & Megginson, 2001) (Esty, Chavich, & Sesia, 2014). The successful financing of this project, would also mark the establishment of project finance as the preferred method to financing infrastructure and other large-scale projects (Kleimeier & Megginson, 2001).

Statistically, the value of project finance transactions has grown from less than US$10 billion per year in the late 1980s, to almost US$328 billion in 2006 (Esty & Seisa, 2007). More recent data indicates that growth over the course of the last few years has been more pronounced – with capital expenditures financed via project finance totalling US$415 billion in 2013 (Esty, Chavich, & Sesia, 2014). Put differently, this means that the value of the loan class has grown at a compound rate of 8 percent over the past 15 years. This has come notwithstanding the realisation of several global macroeconomic crises.

From a regional perspective, Asia, Western Europe and North America comprise the largest project finance markets. Drawing on Esty, et al (2014), Table 1 outlines the dollar value of total project finance investments, by region, in 2013. In that year, capital expenditure in Asia totalled US$286.7 billion, with values in Western Europe and North America being recorded at US$220.1 and US$125.9, respectively. Although project finance investments in Africa only totalled US$41.0 billion, it's a figure that increased almost four-fold from that at which it was recorded the previous year.

Table 1: Project Financed Investment by Region, 2009 - 2013

Region	2009		2010		2011		2012		2013		2009 – 2013		2009 – 2013 CAGR
	$Bn	%	$Bn	%	$Bn	%	$Bn	%	$Bn	%	$Bn	%	
Asia	44.3	32	84.1	40	66.9	31	48.1	24	43.2	21	286.7	30	-0.6
West Europe	35.5	26	59.1	28	50.6	24	37.0	19	37.9	19	220.1	23	1.6
North America	11.7	8	19.5	9	25.0	12	29.7	15	40.0	20	125.9	13	36.0
Australia/New Zealand	12.3	9	14.6	7	24.8	12	43.4	22	20.4	10	115.6	12	13.6
Middle East	14.2	10	15.8	8	14.4	7	11.6	6	33.3	16	89.3	9	23.8
Americas	8.3	6	6.1	3	13.4	6	9.6	5	11.4	6	48.8	5	8.1
Africa	6.9	5	4.7	2	5.8	3	13.4	7	11.0	5	41.9	4	12.3
Eastern Europe	5.8	4	4.4	2	12.6	6	5.9	3	6.7	3	35.5	4	3.6
Total	139.2	100	208.2	100	213.5	100	198.7	100	204.0	100	963.6	100	10.0

Source: Adapted from Esty, et al., 2014

A similar narrative has been playing out in other emerging and frontier markets, where more than 200 deals, with a total value of over US$130 billion, were signed in 2010 across the nations that comprise the 'BRICs' (Brazil, Russia, India, and China,) economies, emerging Europe, as well as frontier markets in Africa, Asia, the Gulf, and Latin America (Ansar, 2011).

Ansar (2011), notably argues that project finance is here to stay as one of the "most significant sources of long-dated financing in emerging markets."[5] This sentiment is attributable to the considerable infrastructure requirements in these economies. The section that follows will explore these requirements in more detail – focusing specifically on sub-Saharan Africa, which is the region that this paper concerns itself with.

2.2. Sub-Saharan Africa's Infrastructure and Financing Requirements

Infrastructure is seen as an important enabler of economic growth by, amongst other means, easing the cost of transport and enhancing trade (Tamaki, 2013). Infrastructure development is particularly important in emerging economies, where high growth rates are required to bring about improved levels of social and economic development. Despite its apparent benefits, it has been estimated that the poor state of infrastructure in Africa inhibits economic growth by 2 percent per year and reduces private sector productivity by 40 percent (World Bank, 2010).

In order to bridge the infrastructure investment gap, the McKinsey Global Institute has estimated that US$57 trillion of infrastructure investment is required on a global scale, between 2013 and 2030 (McKinsey Global Institute, 2013)[6]. The figure put forward by the Organisation for Economic Co-operation and Development (OECD) is even larger, estimating that an

[5] Ansar (2011), p. 3.
[6] Here infrastructure includes transport, telecommunications, power, water and sewage infrastructure

investment spend of US$71 trillion will be needed to improve infrastructure through to the year 2030 (OECD, 2007)[7].

With regards to sub-Saharan Africa in particular, it is estimated that the cost of addressing the region's infrastructure deficit would be US$38 billion per year, while the cost of maintaining existing infrastructure would require further annual investment of US$37 billion (World Bank, 2013). Given current investment levels, this implies that sub-Saharan Africa faces a financing gap of approximately US$35 billion per year, with investment in the sub-sectors of energy, transport, and water capacity being the most pressing (World Bank, 2013).

Considering that the energy industry forms the basis of a stable economy (Kebede, Kagoshi, & Jolly, 2010), arguably the most crucial of the sub-sectors requiring investment attention is the power sector, which is significantly underdeveloped. The World Bank notes that sub-Saharan Africa, which comprises of 48 countries and over 800 million people, at present has an aggregate generating capacity of 68,000MW of electricity, a figure that is roughly equivalent to the power generated by Spain – a country of only 45 million people (World Bank, 2013).

For the region to sustain its economic growth levels – growth domestic product (GDP) growth has averaged 5.5 percent over the past decade, according to the International Monetary Fund (IMF)[8] – increased investment in Greenfield power infrastructure development, including renewable energy is required. Renewable energy has emerged as a significant power source in both the sub-Saharan Africa region and other developing countries (UNEP, 2015).

According to the United Nations Environment Protection Programme's (UNEPP) Global Trends in Renewable Energy Investment 2015 report, an aggregate amount of US$131.3 billion worth of renewable energy investments was recorded across developing countries in 2014 – signifying a year-on-year increase of 36 percent (UNEP, 2015).

This uptake was largely driven by the emerging players that comprise the BRICS economies (excluding Russia) – where investment levels recorded in China, Brazil, India and South Africa

[7] Here infrastructure includes road, rail, telecommunications and energy infrastructure
[8] World Economic Outlook, April 2015

were the highest, respectively; and, numerous frontier markets, including Kenya. (UNEP, 2015).

Nevertheless, despite these investment trends, there remains a strong need for power as well as other forms of infrastructure development in sub-Saharan Africa. This challenge is exacerbated by the region's capacity for raising the required funds in order to fund such development.

Traditionally, local governments, multilateral organisations and donors have been at the helm of financing infrastructure development in the region (Haley, 2013). However, the landscape has begun to change as governments seek to address their public deficits, thus constraining the availability of finance for infrastructure spending (Sy, 2013) (Esty, Chavich, & Sesia, 2014).

Furthermore, donors have become more inward looking following the global financial crisis of 2008/09 and the consequent economic stagnation in many developed countries (Haley, 2013). The financial crisis not only constrained donors, but also sources of private investment, as banks have been required to tighten their lending requirements and limit their risk exposure (Esty, Chavich, & Sesia, 2014).

The challenge for sub-Saharan Africa thus lies in attracting private sector participants to develop Greenfield projects in its constituent – often capital-starved – countries; a feat that would only be achieved if sub-Saharan Africa, as a region, promotes bankable projects (Sasraku, 2013). According to the Global Infrastructure Basel, 'this is the main prerequisite for unleashing private funding for sustainable infrastructure' (GIB Foundation , 2014)[9].

As has already been noted, Smith (2010) highlights that in order for a project to achieve bankable status, the economic feasibility of the project must be considered. In particular, this requires that the project generates sufficient cash flow to cover the projected debt service payments over the entire financing period.

As such, in order for a project to be deemed bankable, an accurate valuation of a given infrastructure investment, needs to take place first. Assuming that the undertaking is backed

[9] GIB Foundation (2014), p. 7.

by project finance, the valuation process is centred on estimating the future cash flows of the project, which will determine its NPV and credit worthiness.

2.3. Unique Risks affecting Project Finance investments in Emerging and Frontier Markets

A project finance investment is exposed to a vast number of risks throughout each stage of the project's development. Starting at the pre-construction phase – which places emphasis on the project sponsor as well as the engineering, design and construction contractors; through to the post construction phase – which, amongst other things, focuses on price and supplies of raw materials and the output market (Fight, 2006).

As per the academic sources from which they have been compiled, these risks can be categorised as being either technical, environmental, economic, or political in nature (Lu, Wu, Chen, & Lin, 2000) (Smith & Walter, 2003) (Fight, 2006) (Pietz, 2010). Figure 2 represents a summary of these heads of risks, before they are outlined in more detail below.

As it is suggested that a number of these identified risks are heightened when undertaking project finance investments in emerging countries vis-à-vis industrialised countries (Hoffman, 2001), reference will also be made to such risks where applicable.

Figure 1: Project Financing Risks

1. Economic Risks Construction Cost Overrun Risk Construction Delay Risk Construction Design Alteration Risk Operational Risk Currency Risk Commodity Price Risk Input or Throughput Risk	**2. Environmental Risks** Risk caused by Environmental Effects on / of a Project Force Majeure Risk Health and Safety Risks / Accidents
3. Political Risks Expropriation Risk Currency Convertibility Risk Transferability Risk Political Violence Risk Inconsistency of Government Policies	**4. Technical Risks** Completion Risk (Technical) Underperformance Risk of Breakdown

Source: Adapted from Lu (2000) , Smith & Walter (2003), (Fight, 2006) and Pietz (2010)

The probability of the above listed risks occurring are more likely at certain stages of the project. The initial phase, with specific reference to the construction phase, is generally associated with technical risks and environmental risk (Pietz, 2010).

Technical risk is a term that relates to the engineering characteristics of the project. When technical risks are realised, there is a likelihood that the project might incur cost overruns, or in acute cases, result in the outright failure of the project (Pietz, 2010). This implies that there is completion risk facing the project at this stage.

Beyond technical considerations, Smith and Walter (2003) note that the possibility for a delay in completion or cost overruns should also be considered in terms of other factors. These include strikes, late delivery of equipment and supplies, cost escalation due to lack of skilled labour, and weather.

While environmental risks are present for the entire life cycle of the project, they are pronounced in the initial phase. They can be considered either in terms of the effect that construction of the project has on the environment; or, in terms of force majeure risk.

In the instances of the former, the project has an adverse environmental impact if it, to use an example, contaminates soil and ground water. Purely in terms of financing considerations, this could result in unexpected costs, and in severe cases, necessitate the re-design of the project (Smith & Walter, 2003) (Pietz, 2010). Given the increased level of environmental regulation in emerging markets, this form of environmental risk is significant for certain types of infrastructure projects (Hoffman, 2001).

Meanwhile, force majeure risk relates to acts of God, such as weather calamities or other uncontrollable events that may delay completion, escalate costs, disrupt operations, or result in the failure of the project (Smith & Walter, 2003) (Pietz, 2010).

Once the project has moved into the post-construction phase, economic and political risk become the main consideration. Examples of economic risk include commodity price risk – which could lead to higher input costs; throughput risk – the risk that supply and demand factors may result in tariff shortfall, leading to revenue deficiency; and currency risk (Smith & Walter, 2003) (Pietz, 2010).

Although not particular to emerging markets, currency risk is more prevalent when investing in such countries. The risk should be considered in instances where a project's revenue or cost stream is denominated in multiple currencies, as they will diminsh in value relative to international markets (Hoffman, 2001).

Finally, political risk has to do with the political conditions that surround a project during the financing period. This includes events such as expropriation, political violence, tax changes, labour disruptions, regulatory inconsistencies, or similar events that arise from the political environment (Pietz, 2010).

In a period in which the project finance market has expanded in emerging and frontier countries (see section 2.1), it has done so notwithstanding political risk. This comes due to the assumptions made about the political landscape of host countries located in these markets, which are often viewed as stable. At best, however, such projections should be considered with only a limited degree of certainty, given the nature of the political and legal landscape of these countries (Hoffman, 2001).

Rather than expropriation, there is growing evidence that policy-level tools are instead being used to derive value from project finance or similar investments. Given that instances of expropriation have been reduced to a minimal on account of international law – which is increasingly being enforced – as well as the newly established interdependent growth relationship between emerging and developed countries; host countries are turning to regulatory control, instead of outright seizure. The risk that a given government would unfairly influence the contracts, laws or regulations that govern an investment thus represent the primary political risk in emerging countries (Henisz & Zelner, 2010).

As renewable energy continues to expand into developing countries, it is important for developers and financiers alike to understand the risks posed by these environments.

Having established a requirement for Greenfield energy investments in the sub-Saharan African region, this paper will henceforth deal with the valuation process of these investments; acknowledging that the above identified risks need to be accounted for. This will be approached from both a theoretical and implementation perspective.

2.4. Cash Flow Modelling and Valuation Metrics

The discounted cash flows (DCF) analysis is the most popular technique for estimating the value of investments in assets that are not traded in financial markets, such as large scale infrastructure projects (Copeland, Koller, & Murrin, 2000) (Cheah & Garvin, 2009)[10].

It is based on calculating the present value of future cash flows – thereby taking the time value of money principal into account. The sum of all the future free cash flows, discounted at an appropriate rate equates to the net present value (NPV). This allows for the determination of whether or not a project should be undertaken, based on a basic rule of acceptance or rejection; where all positive NPV projects are accepted and those with a negative NPV forgone.[11]

Beyond the conventional NPV approach, the other criteria applied for the valuation of investments in the built environment, include the internal rate of rate (IRR), payback period, and discounted payback period.

The NPV method, however, is subject to notable limitations when it comes to the proper evaluation of such large-scale projects. This is because the DCF methodology is based on forward looking data, and thus requires a relatively large amount of assumptions about future economic and technical conditions (Cheah & Garvin, 2009).

When applied to risky situations, the precision of such assumptions may have quite large variances. Bock & Trück (2011) argue that the assessment of NPV and cash flows output values does not provide enough information to substantiate an investment decision of a large-scale project in highly uncertain environments, such as developing countries.

The main reason for this shortcoming is that the methodology takes a deterministic approach based on a single set of forecast assumptions (Mun, 2002). These inputs are single values, or point estimates – thus assuming their certainty and not allowing for any margins in forecasting error. The subsequent NPV which is calculated based on these cash flows is similarly a point estimate, with no additional information being provided with regards to its certainty. Put

[10] C.f. Esty (1999) and Samis & Davis (2014) for a discussion on the literature that focuses on real options analysis as being an improved method for valuing large scale projects

[11] Refer to Appendix 2 for the DCF formula.

differently, the method is unable to properly evaluate capital investments, as it does not explicitly capture and treat evolving project uncertainties (Esty B. , 1999) (Mun, 2002).

This suggests that a deterministic forecast is most beneficial when large capital investments are valuated under certainty. Indeed, it has been argued that its use is only applicable in situations where the cash flows of the project are fairly certain, inflation is well estimated, and the overall operational environment is fairly stable (Mooilanen & Martin, 1996).

In reality, however, future cash flows are characterised by risk and uncertainty. The meaning of 'risk' in large-scale capital investment projects should be apparent, however, to be unequivocal, the definition put forward by Wagle (1967) is adopted in this paper; where risk is defined as 'the potential for a project's return to fail to achieve any given rate'[12].

A project's expected return is based on the cash flow forecast of a number of, often inter-related, project variables (Savvides, 1994). The forecasting of cash flows through a given period exposes the projections of both revenue and cost components to risks, thereby limiting their validity. This problem is exacerbated in capital investment valuation given the long life-cycles of these investments. As a result, this can lead to significant errors in valuation (Esty B. , 1999).

This is one of the critical limitations of the deterministic DCF approach and is central to the research of this paper; DCF analysis assumes that ex-ante cash flow forecasts are both predictable and deterministic.

In order to account for the uncertainty in cash flows, academic literature suggests three risk analysis methods with which to supplement the DCF framework, allowing for the identification and quantification of risks pertaining to a capital investment, namely sensitivity analysis, scenario analysis and simulation analysis (Savvides, 1994).[13]

First, sensitivity analysis measures the change in the project outcome (the outcome of interest for this study is the NPV) with respect to movement in the value of a specified input variable.

[12] (Wagle, 1967), p. 14.
[13] Sensitivity analysis is the most popular technique

This is achieved by varying the value of a single input variable. For example, the appraisal of a renewable energy investment may alter the electricity tariff. This allows for identification of the project's high risk variables which will have an influence on the result of the project.

While it is the most popular of the three techniques (Kaka, 1996), it does, however, have numerous weaknesses. Firstly, by focusing on one input factor, it ignores the interactions with other variables; that is, the assumption of ceteris paribus when changing one variable is unrealistic. In addition, analysing the effect on DCF value becomes difficult to interpret in instances where many variables are uncertain (Kelliher & Mahoney, 2000).

As such, it is useful to consider the effects of a number of input variables together to represent an alternative output (Baker & Powell, 2004). Scenario analysis allows for this type of assessment; by calculating various scenarios it is possible to estimate the impact which key input parameter combinations have on the cash flow and NPV (Savvides, 1994). Put differently, scenario analysis looks to develop some estimate of the forecasting risk along with identifying the components that are critical to the project's success.

Other than the already established base case, a best case and worst case scenario is usually constructed to estimate the error in cash flow projections. This is achieved by establishing upper and lower bounds on the various components of the project. While the base case may contain error, the bounds are established with reasonable confidence that that they will not be breached (Damodaran, 2006).

Continuing with the example of a renewable energy investment, such an alternative financial assessment may be constructed by altering the inputs under favourable or disadvantageous energy policy and demand scenarios. Departures from the base case may look at scenarios of high energy prices and increased energy demand – which will produce the highest cash flow scenario; and low energy prices and reduced demand for energy on the downside – to produce the lowest cash flow scenario.

Similar to sensitivity analysis, however, scenario analysis has its drawbacks. Foremost in this regard, is that by incorporating this analysis, not all future scenarios are taken into consideration. Moreover, scenario analysis does not present evidence with regards to the likelihood of these scenarios – or departures from the base case – of being realised (Savvides, 1994).

2.4.1. Monte Carlo Simulation

When evaluating capital investment decisions under conditions of uncertainty, it is important to obtain an overall picture of the probability distribution of the NPV or other valuation criteria used (Hillier, 1963) (Hertz, 1964).

Stochastic or Monte Carlo simulation is an alternative to the DCF valuation methods outlined in the previous section.[14][15] It overcomes the main limitations of these methods in that it allows for risk to be incorporated in the forecasted cash flows of a project; this is achieved by skewing the distributions for a variety of factors in the NPV analysis (Hertz, 1964).

Specifically, Monte Carlo simulation models the main input variables projected in a forecasting model by specifying them with statistical probability distributions. The assigned probability distribution represents the range of possible values that each variable can assume (Baker & Powell, 2004).

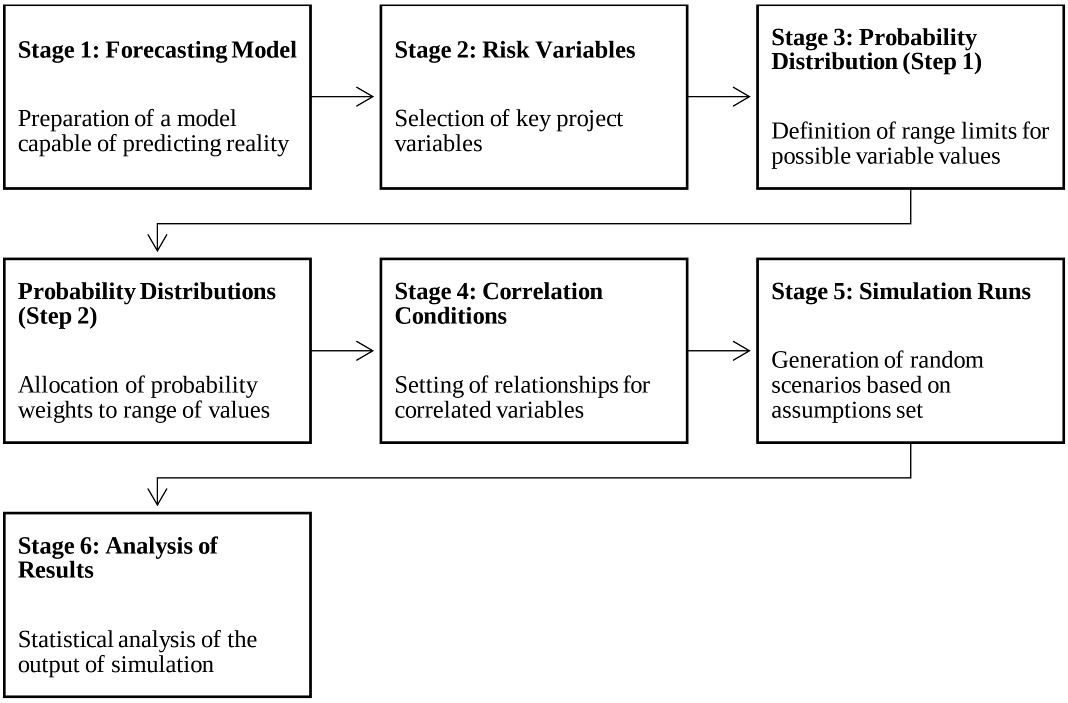
Through random sampling within the distributions, a large number of scenarios are considered with respect to these uncertainties. The technique requires the DCF input variables to be subjected to a number of computer simulation runs, which takes samples for each variable based on the specific probability distributions. Theoretically, this accounts for the variability in cash flows that extend over many years into the future (Baker & Powell, 2004).

The resultant output of the computer simulation is a calculated probability distribution for quantities chosen to be forecasted. That is, they represents the probability of success or failure of the forecast quantities, rather than a single-point estimate. These forecasted values, for example, can be the cash flow from a specified period during the life of the project, or other investment valuation criterion, such as the overall project NPV or IRR (Baker & Powell, 2004).

[14] The term 'Monte Carlo method' is a reference to the Principality of Monaco, which is famous for its casinos. It was first used by Stanislaw Ulam and Nicholas Metropolis to indicate the element of chance with which the method is associated with (Metropolis & Ulam, 1949).
[15] The concept of Monte Carlo simulation is quite general, and as such its technique is applicable to solving a variety of problems across various fields. This paper only considers Monte Carlo simulation within the context of cash flow modelling.

The specific process necessary to implement a Monte Carlo simulation is outlined below. This is provided for, given that the incorporation of the Monte Carlo procedure into the model presented in this paper forms the basis for the valuation of the project. As per figure 3, the simulation process involves six distinct stages.

Figure 2: The Monte Carlo Simulation Process



Source: Adapted from Savvides (1994)

The first stage requires that a forecasting model of the project is created. A forward looking model must be capable of predicting the cash flows over a given time period. It connects the input variables with output measures though logical formulae (Savvides, 1994).

In stage two, it is necessary to select the parameters which are to be treated as uncertain. Such risk variables can be defined as those which are important to the project's success. A small change in value from its projected value has a strong influence on the economic feasibility of the project (Savvides, 1994). As has already been noted, sensitivity analysis is most commonly used to identify the individual variables which affect the project's outcome.

However, if meaningful results are to be garnered from conducting a sensitivity analysis, the likelihood of the uncertainty of the variable being tested should also be considered. This comes as highly sensitive variables may not have an element of uncertainty (Savvides, 1994). For example, the purchase price of electricity may be very significant to a return on a renewables project, but the likelihood of a downward movement in the price of electricity is unlikely if the off-taker is contractually bound to purchase the output at a predetermined rate.

Furthermore, García-Cascales, et al. (2014) notes that it is important to limit the number of stochastic variables introduced at this stage, primarily because a large number of probability distributions will increase the variance in output values. As such, only the most influential and uncertain inputs should be described by probability distributions.

In stage three, probability distributions are estimated for the uncertain input variables. While it is not possible to accurately forecast the exact value that an input variable may assume in the future, it is possible to account for the realised value within the parameters of an appropriate probability distribution.

Fitting the probability distribution requires that certain estimations be made regarding the critical variables. In particular, this involves setting limits on the value that a given risk variable may assume; and secondly, allocating probability weights to it (Savvides, 1994).

When establishing range limits, it is necessary to estimate the degree of uncertainty in the key variables. The limits – which are the minimum and maximum boundaries on an identified risk variable – indicates the level of variation possible. The decision on what exactly these limits are is usually based on expert judgement and subjective opinion.

In garnering this level of information, experts need to be surveyed; where responses to the question 'what values are considered to be the highest and lowest possible for a given risk variable?' are required[16] (Savvides, 1994).

If the estimated probability distribution is one which apportions probability towards the central values (the aspect of probability allocation is elaborated upon hereafter), such as the normal distribution – it is useful to consider the widest range limits that are drawn from the survey. Conversely, if the probability distribution used is one which apportions probability evenly

[16] The Delphi Method technique is considered suitable for this purpose

across the range limits, such as the uniform probability distribution, then the narrower range limits should be considered.

The next step involves allocating the probability of occurrence for the established range of values. As each value within the selected range has an equal chance of occurring, the employment of probability distributions regulates this likelihood (Savvides, 1994).

The selection of a probability distribution is underwritten by the expectations of the outcome of a particular future event. They can be classified into two categories, namely symmetrical distributions, and the step distribution (Savvides, 1994).

Symmetrical distributions establish the probability evenly within the defined range with differing emphasis towards the centre values. Bailey, et al (2000) notes that in the case of most project variables, variability characteristics are sufficiently explained by the employment of a symmetrical distribution; the most common of which are the normal, uniform, triangular and pert distributions. Each of these probability distributions are displayed graphically in Figure 3 below.

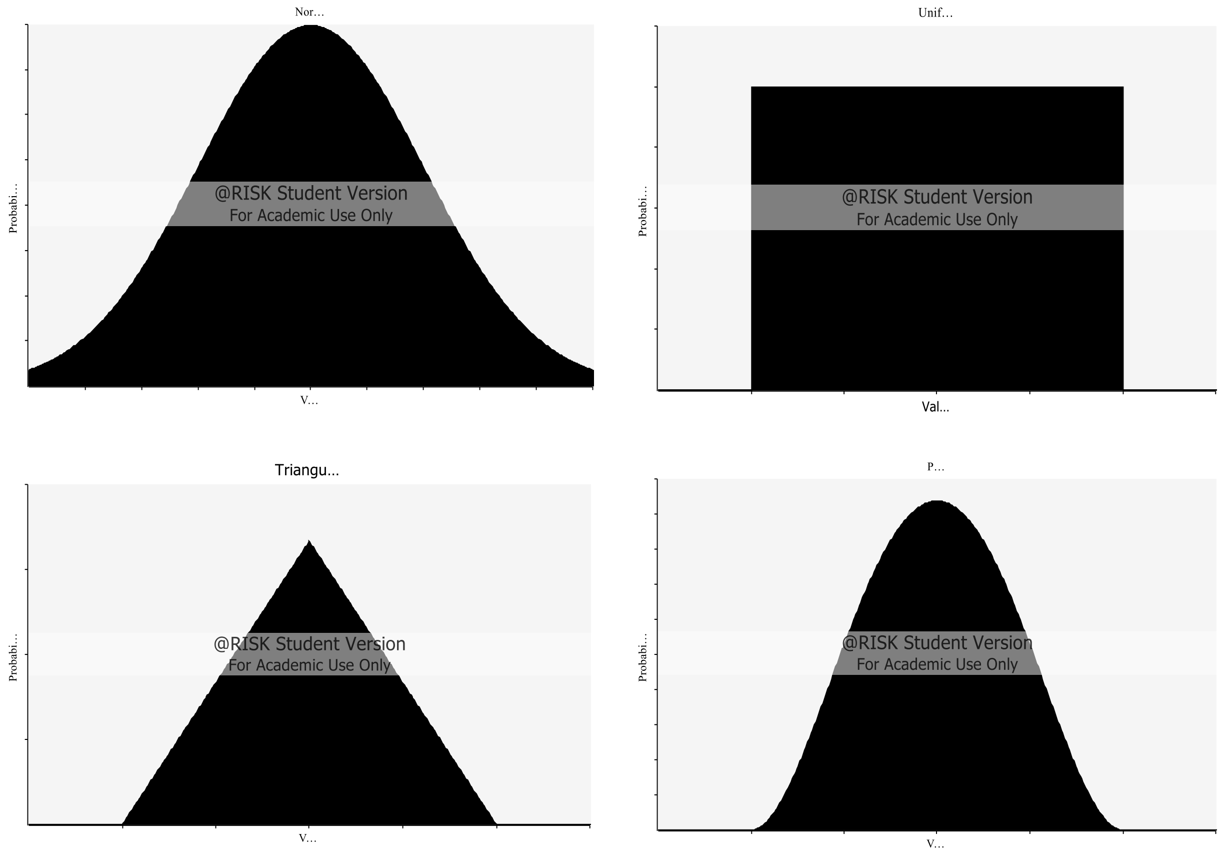
The normal distribution is used when the occurrence is centred on the middle values. Examples of variables described by the normal distribution include inflation rates and energy prices (Bailey, Couët, & Lamb, 2000).

The simplest distribution used for sampling a range of estimates is the uniform distribution. This comes as every value, ranging from the minimum to the maximum, has an equally likely possibility to occur – as is indicated by its rectangular shape. A uniform distribution is useful in situations in which minimum and maximum estimates are available, but without having other information on the variable – such as a most likely estimate (Bailey, Couët, & Lamb, 2000).

The triangular distribution describes a situation in which the maximum, minimum and most likely values to occur are all known – with the distribution favouring the most likely value. Graphically, this distribution gives the impression of a triangle – with the value which has the highest probability of occurring represented at the point of the triangle (Bailey, Couët, & Lamb, 2000).

Meanwhile, the triangular distribution, is similar in nature to the PERT distribution in that it also emphasises the most likely value, supplementary to maximum and minimum estimates. However, it is designed to generate a distribution that is more similar to a realistic probability distribution (Bailey, Couët, & Lamb, 2000).

Figure 3: Common Probability Distributions Used in Risk Analysis



Source: Own Work

Stage four involves describing the correlation between the input variables. It is said that there is a correlation between two variables when a change in one variable induces a change in the other. This consideration is important because the selection of input values from the assigned probability distributions for each variable is random. Thus, it is likely that certain risk variable inputs are generated for certain scenarios that violate the correlation between the variables – distorting the results of the simulation process (Savvides, 1994).

Given this, for a Monte Carlo simulation to produce reliable results, the correlations need to be described, and where necessary, constraints to the simulations need to be applied. By incorporating such a provision, it limits the random selection of values from the selected probability distributions, in effect controlling the simulation so that the correlation relationship of the identified variables are not upset (Savvides, 1994).

In stage five, the simulations are performed, generally with the aid of computing software. During the simulation, the values of the variables are selected, at random – based on the specified probability distribution. This process is done repeatedly, until sufficient results have been gathered to compile a sample which is representative of the near-unlimited number of scenarios possible. The output generated is the probability distributions of future cash flows and of the expected NPV of the project (Savvides, 1994).

Finally, in stage six, the analysis of the results is performed. The cumulative probability distribution of all the cash flows paths is graphically displayed and is used to statistically determine downside and upside risk; that is, if the probability that the valuation outcome would be below or above a certain value. As such, the method provides for an assessment of overall project risk (Savvides, 1994).

Given the presence of input factors that are affected by a high level of uncertainty, Monte Carlo simulation seems like the ideal approach for valuation in emerging markets. However, the technique is not applied without shortfalls.

This comes as it is difficult to identify the inter-relationship between parameters when little empirical evidence is provided markets. Secondly, the estimation of the underlying probability distributions markets is an ever more challenging discipline. Finally, the volatile nature of emerging markets also render the estimation of the possible value range, as well as the expected value, very arbitrary (Gimpel, 2010).

2.5. Credit Risk Metrics

The setting of international capital-adequacy standards for large banks through the various Basel iterations, as put forward by the Basel Committee on Banking Supervision (BCBS), has required new approaches to the management of banks' project finance loan portfolios.[17]

[17] Basel refers to the Bank of International Settlement (BIS)

As per the Basel II Accord, the capital requirement is relative to measurements of credit risk; the higher the risk the more capital is required – thereby promoting financial stability. This suggests an approach that allows for greater use of risk assessments provided by banks' internal rating systems (Yescombe, 2002).

Termed the internal ratings-based approach (IRB), banks may rely on their own estimates of risk components in determining the capital requirement for a given risk exposure. The risk components include probability of default (PD), loss given default (LGD), exposure at default (EAD), and effective maturity of exposure (M) (Yescombe, 2002).[18]

2.5.1. Probability of Default

The PD is an estimate of the likelihood that a default event will occur. This estimate applies to a particular time horizon, usually one year (Gatti, 2013).

Under the Basel II framework, an obligor defaults on credit either when they are unlikely to pay the obligation, or secondly, if the obligation is overdue by more than 90 days (BCBS, 2005). Given such circumstances, the loan agreement underlying a project's financing usually specifies that lenders are allowed to take action against the project company (Yescombe, 2002).

Indicators of project default are used to determine the likelihood of non-payment of interest and principal in a given period. Fabozzi (2008) notes that the debt service coverage ratio (DSCR) is considered as the best indicator for this purpose.[19]

In the structuring of project debt, the amortisation profile is designed to deliver an expected value of DSCR. The credit risk which characterise project finance investments is represented by the ex-post DSCR, which may differ from its ex-ante measures. On average, the ex-ante DSCR ranges between 1.35 and 1.40 (Gatti, 2013).

By incorporating a stochastic modelling approach, it is possible to identify the PD through the simulation of the project's cash flows. Interested readers are referred to section 4.3, where the ex-ante default probabilities of the case study are quantified.

[18] Only PD is covered in this paper
[19] Refer to Appendix 1 for the DSCR formula

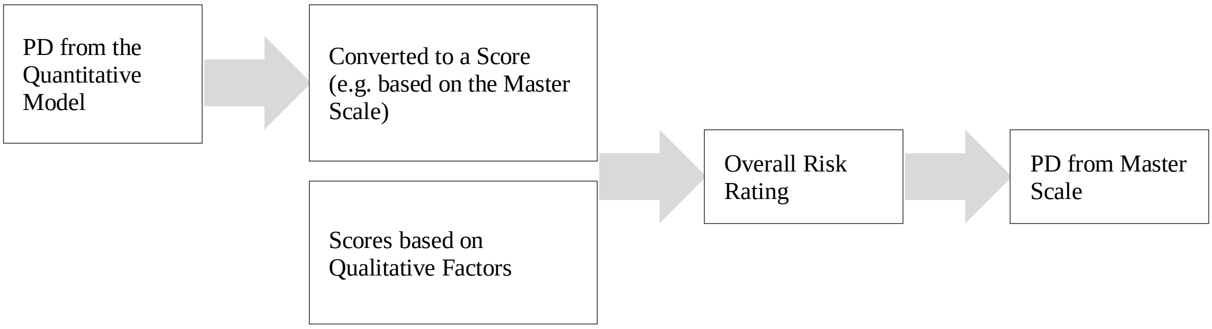
2.5.2. Credit Ratings

Pillar I of the Basel II Accord requires the establishment of an internal risk rating system (IRRS). In this way, banks can categorise obligors into standardised risk groups, which represents the relative likelihood of default (BCBS, 2005).

This requires the construction of an ordinal, relative ranking of the ability of the project company to service debt. In specialised lending exposures, such as project finance, hybrid frameworks are used – where the PD derived from the quantitative model is complimented with a qualitative overlay of fundamental credit risk factors that would affect a project company's ability to pay its debt (Ozdemir & Miu, 2009).

The quantitative model generates an absolute value of PD. This value is converted into a quantitative score, based on a master rating scale (Ozdemir & Miu, 2009). In turn, this score is then combined with the scores arrived at from the evaluation of qualitative factors to realise an overall rating. A schematic depiction of this process is presented in figure 5.

Figure 4: Overall Risk Rating Process



Source: Adapted from Ozdemir & Miu (2009)

The overlay considers soft, qualitative factors that are based on expert judgement. Generally, the factors considered are born out of the risk facing project finance investments, which were outlined in section 2.3 of the literature. For example, the project's completion risk may be rated from certain parameters, such as the reputation of the engineering, construction and procurement (EPC) contractor. Mohamed & McCowan (1999) suggests the incorporation of such macro and project-specific risk factors into the project structure is critical in determining a project's credit worthiness.

The combined PD is mapped to internal ratings, based on pre-specified PD ranges assigned to each risk rating. This provides a common base for comparing a project's creditworthiness. For the case study which this paper analyses, the credit rating determined in sectoin4.4. It is mapped to the DBSA's master rating scale presented in figure xx.

The organisation uses a 17-point scale which is used to assign a rating to the PD. The scale is in line with external ratings provided by Fitch, Moody's, and Standard and Poor's (S&P). The grades can be classified as either being low, medium, high or default risk.

Specifically, the grades denoted MS1 through MS4 are considered low risk grades – falling between a AAA and AA- rating when mapped to the S&P scale; MS5 – MS13 are medium risk grades (A+ and BB-); MS14 – MS17 are high risk (B+ – CCC); and, finally a default grade (D).

Table 2: DBSA Master Rating Scale

Grade	PD	Lower bound PD	Upper bound PD	S&P	Moody's	Fitch
MS1	0.01%	0.00%	0.02%	AAA	Aaa	AAA
MS2	0.02%	0.02%	0.03%	AA+	Aa1	AA+
MS3	0.03%	0.03%	0.04%	AA	Aa2	AA
MS4	0.04%	0.04%	0.05%	AA-	Aa3	AA-
MS5	0.05%	0.05%	0.06%	A+	A1	A+
MS6	0.06%	0.06%	0.08%	A	A2	A
MS7	0.10%	0.08%	0.14%	A-	A3	A-
MS8	0.17%	0.14%	0.24%	BBB+	Baa1	BBB+
MS9	0.30%	0.24%	0.40%	BBB	Baa2	BBB
MS10	0.50%	0.40%	0.68%	BBB-	Baa3	BBB-
MS11	0.85%	0.68%	1.13%	BB+	Ba1	BB+
MS12	1.40%	1.13%	1.90%	BB	Ba2	BB
MS13	2.40%	1.90%	3.20%	BB-	Ba3	BB-
MS14	4.00%	3.20%	5.50%	B+	B1	B+
MS15	7.00%	5.50%	9.50%	B	B2	B
MS16	12.00%	9.50%	16.00%	B-	B3	B-
MS17	58%	16.00%	99.00%	CCC	Caa	CCC
D	100%	100%	100%	Default	D	Default

Source: Development Bank of Southern Africa, 2014

It has been found that the addition of the quantitative overlay should increase the overall performance of the model. The primary reason for this is because it incorporates additional information which are not captured by a quantitative model (Ozdemir & Miu, 2009).

3. RESEARCH METHODOLOGY

Following the review of the current body of literature on the topic of project finance, which established the rationale for conducting this research; this section sets out the methodology which has been used for this research undertaking.

Specifically, the research approach and strategy, data collection process employed and justification of the data analysis method is outlined. Thereafter, the strengths and limitations of conducting the research experiment are highlighted.

3.1. Research Approach and Strategy

The design of the proposed research is explanatory in nature using a quantitative design. This approach was adopted due to the thin body of literature focusing on project finance valuation, and the fact that no such research has been conducted on the valuation of project finance investments in emerging markets.

The adoption of this approach would allow for logical inferences to be drawn about the methods that are available to value project finance investments from the data used.

3.2. Data Collection

In order to test the research question, this paper uses a project finance valuation model which has been developed to value an actual infrastructure investment located in South Africa. This investment is the case study upon which the empirical component of this paper is based.

Both the model, and other specific details about the project has been provided for by the DBSA – which were the main lenders in the project, having extended senior, junior, and mezzanine loans to a combined value of more than ZAR164 million. [20]

Prior to the provision of the model, three representatives of the DBSA credit department provided a demonstration of the model's functionality.[21] Thereafter, permission was requested,

20 Refer to Table 2 for project details

[21] Meeting conducted on the 12/6/2014 for the purposes of demonstrating the organisation's project finance rating model. Meeting attendees included C. Van Biljoen (Manager, Credit Analytics, DBSA); A. Rao (Risk Analyst, DBSA); H. Ngoasheng (Credit Model Technician, DBSA); and, J. de Villiers (author/researcher)

and subsequently granted from the organisation's Chief Risk Officer (CRO) to use the model for the objective of conducting the research.

3.3. Data Analysis Methods

Due to the nature of this paper, a number of elements of the methodology, specifically the data analysis method, has already been elaborated upon in the literature review – where justification for the valuation metrics were presented.

With this in mind, the analysis of the project valuation model focuses chiefly on the key model outputs of the NPV of the project, the PD of the borrowers – both of which deal with the effects that a simulation process has on project valuation; and, the overall credit rating of the project – which considers other contextual factors, such as country, environmental and social risk in the project dynamic.

Beyond detailing the setup of the valuation model and the incorporation into the Monte Carlo procedure, this dissertation also examines the main input variables that affect project valuation. As will be presented in the sections that follow, due to the complication of many of these underlying variables, it is necessary to incorporate a stochastic process in order to generate a probability distribution of possible outcomes.

3.4. Research Reliability and Validity

According to Joppe (2000), in terms of quantitative research, in order to ensure the quality of the study, the research must achieve measures of both validity and reliability. The first, validity, is defined as the extent to which a concept is accurately measured in a quantitative study.

Given this, two aspects need to be considered regarding the validity of this research undertaking. The first, relates to the correct valuation of the case study project after uncertainty has been accounted for. That is to say, the valuation outcome derived after the Monte Carlo simulation procedure has been applied.

It is argued that the measure of validity is met, given that the valuation model follows the fundamental steps in incorporating the Monte Carlo procedure – as has been outlined in Section 2.4.1 of the literature review.

The second aspect pertaining to the validity has to do with the valuation results that are derived for the base case study. This is an important component of the research, as it is necessary to provide a fair basis from which to compare the simulation results against.

In terms of the base case valuation, it is again argued that the measure of validity is attained. This comes as the valuation model presented is considered deterministic up to the point where simulations are run. This deterministic model produces cash flow forecasts based on assumptions, which are used to calculate the relevant base case outputs. The assumptions used for the cash flow forecasts of the investment are outlined in Section 4.3.1.

It is further noted, that the valuation model was developed by the DBSA – one of the largest financiers for Africa's infrastructure. The financial loss of incorrectly valuing a project such as the one presented in this paper could be significant, thus it should be accepted that the valuation was accurate.

The second measure of quality in a quantitative study is reliability. This refers to the accuracy of the model, or the extent to which the same results will be produced if it is used in similar situations (Joppe, 2000).

This pre-requisite is not entirely applicable to this research undertaking, given that no simulation will produce the same results twice. The simulations have been run within the framework of the valuation model already provided by the DBSA.

However, it was required to run one simulation outside of the model. This was done in order to generate a graphical output of the NPV distributions of the project – which was not presented in the original model; this instead only presented the numerical values of the cash flow distributions over the relevant time period.

In order to compensate for this, this simulation of the cash flow was run with the exact same parameter specification of the original model; where the cash flows were influenced by the identified risk drivers using unchanged probability distribution and 10,000 iterations during the simulation process. [22]

As such, this is not a consideration regarding the reliability of the research undertaking. Indeed, when comparing the graphical output derived from the simulation run externally to the numerical cash flow outputs that were presented within the DBSA's valuation model, they are near indistinguishable; both in terms of their probability distribution of returns and, with regards to their mean and standard deviation – which are close to being equal.

3.5. Limitations

The primary limitation of the results is that the simulation output is limited to those derived from the case study. This comes as the input factors underscoring the simulation procedure were particular to the case study and, generally speaking, these factors cannot be extended to the valuation of other projects.

However, a select number of these factors; which can be considered as more general, or macro, in nature have been taken into account in both the running of the simulation and the credit risk scoring processes.

It is argued that these factors have applicability to all types of infrastructure projects – and especially wind farm investments – that are being constructed in both South Africa and other emerging countries. Indeed, only the parameterisation of these factors would need to be re-specified to reflect the reality of the project to allow them to be integrated as a consideration into project appraisal.

While it is the purpose of this paper to showcase the methodology behind incorporating a stochastic approach to valuation, if common factors exist with other projects, it is argued that the valuation – and for that matter the credit risk analysis – of the case study serves as a recommendation or best practice example.

22 The simulation was run using @Risk® software (version 6.3.1) developed by Palisade Corporation as the risk analysis tool (Palisade Corporation, 2010).

4. RESEARCH FINDINGS, ANALYSIS AND DISCUSSION

4.1. The Investment Opportunity

In a bid to promote private sector investment in the renewable energy space, the South African government introduced a competitive tender process in 2009 – which afterwards would become known as the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) (Eberhard, Kolker, & Leigland, 2014).

Across three phases of bidding, the initiative awarded a total of 64 renewable energy projects to the private sector, requiring an aggregate financing commitment of US$14 billion. This was financed predominantly via project financing by Development Finance Institutions (DFIs) and South African commercial banks. Upon completion, the projects would generate 3922 megawatt (MW) of renewable power to feed into the country's national grid (Eberhard, Kolker, & Leigland, 2014).

In 2011, the first phase of the bidding process concluded – allocating a total of 28 bids which were earmarked to produce 1,416 MW of renewable power and requiring a total investment of US$5.97 billion. Of these, twenty projects, combining for 682 MW, were based on solar technology – either photovoltaic (PV) or concentrated solar power (CSP); and, eight project employed wind technology, totalling 634 MW (Eberhard, Kolker, & Leigland, 2014).

The investment opportunity is one of the eight wind power projects that were allocated in the first round. While information detailing the project, such as documents and contracts were fortunately available for the writing of this dissertation at the request of the DBSA; in order to respect the privacy agreement, no reference will be made to the name of the project, company and other stakeholders which participated in this project, unless such information has been made publicly available.

In terms of the quantities mentioned, however, the numbers reflect the actual investment made; the purpose of this dissertation is to illustrate the methodology for valuation based on exact numbers and risk considerations.

4.2. General Project Information

A brief introduction to the case study is provided for, addressing the particulars of the project and the assumptions made regarding the cost and revenue components. These are based on the project's term sheet and form the general input parameters of the cash flow model.

In terms of timeline considerations, the project was set to commence in November 2012 with the construction period lasting 18 months before operating revenues could be generated. The project has a life-cycle of 20 years, and correspondingly, total depreciation is to be realised across this 20 year period.

Over this time period, it is the assumption that no additional generational capacity is introduced to the wind farm and, therefore, this factor is constant over its 20-year lifetime.

The macro risk factors affecting the valuation of the project are framed in the context of the risk posed by the South African environment. Both the currency of funding and operating currency is the South African Rand (ZAR), and as such, currency risk is not a consideration. However, the project has to consider taxes of the host country, where the applicable rate for companies is 28 percent.

Several other aspects are considered regarding the assumptions. Table 2 provides a summary of these and further relevant general input parameters for the project model, as per the project's term sheet.

Table 3: General Parameters

Project sector	Energy
Project start date	01/11/2012
Currency of funding	ZAR
Operation currency	ZAR
Project lifetime (years)	20
Financing tenor (years)	17
Construction period (months)	18
Country of major project risk	South Africa
Tax rate	28,00%
Asset depreciation time (years)	20

Source: Development Bank of Southern Africa, 2014: Project Loan Term Sheet

One fundamental issue in securing the project financing from the DBSA and other stakeholders is determining the amount of debt that can support the project cash flows. As per the financing parameters, it established that the project would be financed with ZAR630 million of debt; which comprised of ZAR573,030,664 in senior debt, ZAR13,000,000 in junior loans and ZAR44,000,000 in mezzanine financing[23].

The lenders do not provide debt in different tranches, instead it was incurred in the initial year of the project and matures in either 12 or 17 years – depending on the product. Interest payments on each debt product are paid semi-annually and are a floating percentage of the remaining principal each year. The six-month Johannesburg Interbank Agreed Rate (JIBAR) is the reference rate used to determine the interest charges.

Table 3 provides the financing parameters of the project, which highlights the information necessary to understand the financial structure of the project. These considerations are important when making assumptions in the cash flow model.

Table 4: Financing Parameters

Product type	**Senior**	**Mezzanine**	**Junior**
Total volume	573 030 664	44 000 000	13 000 000
Product start date	2012-11-01	2012-11-01	2012-11-01
Product tenor in years (including grace periods)	17	12	12
Interest rate type	Floating	Floating	Floating
Floating reference rate	JIBAR 6 months	JIBAR 6 months	JIBAR 6 months
Floating rate fixing frequency	Semi-annually	Semi-annually	Semi-annually
Construction phase margin on floating rate in bps	500	900	600
Operation phase margin on floating rate in bps	480	900	600
Amortisation type	Straight line amortisation	Straight line amortisation	Straight line amortisation
Bullet amount at maturity (in % of principal)	0,00%	0,00%	0,00%
Interest compounding frequency	Quarterly	Semi-annually	Semi-annually
Capital grace period (in months)	24	24	24
Interest grace period (in months)	0	0	0

Source: Development Bank of Southern Africa, 2014: Project Loan Term Sheet

4.3. The Project Finance Cash Flow Model

Along with the project information, the cash flow model for the project has been developed by the DBSA. The model incorporates the aspects of valuating a project finance investment that have been elaborated on from a theoretical perspective in the section covering the relevant

[23] According to The European Wind Energy Association (2013) (EWEA), in general, the terms of the three debt instruments can be surmised as follows: Senior debt - the lender is to be paid interest and principle repayments from project cash flows prior to the other creditors being paid; Junior loans – subordinated to the senior debt and, as such, the capital and interest payments associated with the loan is to be paid subsequent to those of the senior debt holders; finally, Mezzanine debt – is junior to other forms of debt and a hybrid between debt and equity.

academic literature. Essentially, it is an advanced valuation model based on stochastic cash flow modelling. It provides an accurate framework with which to test the research question.

In describing its structure, this section will analyse the model – addressing its specific components in functioning order, namely its input component, followed by the computation component, and finally, the output component. These facets are discussed within the context of the aforementioned investment opportunity.

4.3.1. The Input Component

Starting with the input component of the model, the project's cash flows are forecast based on assumptions. It is thus required that the project's input parameters be identified. Two dimensions of input parameters are distinguished, namely the parameters regarding the general specification of the model – which are used to determine the project's free cash flow; and, input parameters regarding the simulation procedure – in order to account for uncertainty.

Construction of the project is expected to occur over a 12 month period. Construction costs have been modelled as being higher in the initial period, before tapering off in subsequent quarters. By the end of the construction stage, the total costs associated with this phase are expected to total ZAR219, 342, 457.

Table 5: Construction Cost Schedule

Period	**Date (end of period)**	**Construction cost schedule (in ZAR)**
1	2012-11-01	136 863 275
2	2013-02-01	33 661 346
3	2013-05-01	33 661 346
4	2013-08-01	7 578 245
5	2013-11-01	7 578 245

Source: Development Bank of Southern Africa, 2014

However, in reality, there are numerous factors that could have an affect on the cash flow during the construction period and that need to be accounted for. These include cost overruns, time delays and the realised values of cost and revenue components that differ from what has been budgeted for (Bennett & Ormerod, 1984).

To account for this, the model introduces a number of risk drivers into the analysis, upon which Monte Carlo simulations will be run. Each event is considered in terms of its frequency and impact it will have on the project. This is measured with regards to its frequency of occurrence: how long the delay is expected to occur for – effectively measuring how long the revenues will be impacted; and, what the associated cost will be to resolve the event.

As has been noted in section 2.5.1, which covered the literature on the Monte Carlo simulation procedure, the identification of these risk factors, as well as the range limits describing them, are based on subjective opinion and expert judgement of practitioners with knowledge of such projects. In the instance of the case studies, they have been identified by practitioners within the DBSA (Van Biljoen, Rao, & Ngoasheng, 2014).

The simulation parameters for the construction phase include, weather or climate adverse effects, non-delivery of key equipment, rights and license issues, and skilled labour issues. Of these risk variables, the risk that adverse weather or other climatic effects may have on the project's completion is deemed the most significant – given the specific location of this project in the Eastern Cape Province of South Africa, it is determined that the exposure of the project to environmental conditions could affect its completion time and costs.

Table 6: Construction Phase Events

Risk type or event description	Frequency of occurrence	Impact	
		Expected delay	**Expected cost for resolving in ZAR**
Weather /climate adverse effects	7 per y - 1,0 per m	4h - 8h	100K - 1M
Non-delivery of key equipment	2,4 - 4 per y	2d - 3d	100K - 1M
Skilled labour issues	2,4 - 4 per y	18h - 2d	100K - 1M
Potential delay recovery per quarter		0,25	

Source: Development Bank of Southern Africa, 2014

After the 18-month construction period, the project is expected to commence its operational phase, in which the project starts generating revenues. The input parameters used to calculate the cash flows for this phase of the project are outlined in table 6.

Table 7: Summary Input Operations of Wind Farm Investment

Input	Description
1. Revenue = a * b	Tariff: (a) Price per unit in ZAR Production: (b) Volume in units
2. Costs	Maintenance and enhancement costs Machinery and equipment costs

	Labour and management costs and consulting fees Costs for consumable supplies or services

Source: Own Work

The wind farm generates revenues based on two inputs, namely a tariff – which is a combination of a subsidy and the market price for electricity, priced per unit in ZAR; and, the generated electricity in the period – as measured by volume of units produced.

This implies that the project's cash flow is influenced by inputs that are ex-ante unknowns. Therefore, they must be treated as stochastic variables. With regards to the tariff received, it is possible that the valuation of the wind farm project could be adversely affected by the event of a lower electricity price. As such, in conditions of uncertainty, the tariff's components – with specific reference to the price of electricity – would be modelled as a stochastic factor.

However, for this project – along with the other projects commissioned under the REIPPPP – the value of the tariff is fixed at ZAR3.35 per unit, due to the existence of a 20 year power purchase agreement (PPA) with the off-taker, Eskom. Given this, it is not necessary to stochastically model the price of electricity as a risky input variable.[24]

On the other hand, there is uncertainty regarding the volume of electricity produced. While the project has a maximum generating capacity of 11,395,500 units per quarter, it is insufficient to assume that the wind farm operates twenty-four hours a day, seven days a week. This represents the revenue risk to the project.

Similar to dealing with uncertainty in the construction phase, for the operations phase – with specific reference to production uncertainty – risk drivers are introduced into the analysis, upon which Monte Carlo simulation will be run.

The events that could be realised in the operational phase of the project either stem from unexpected maintenance of the wind farm during operation or due to major operational incident. Again, consideration is given to these risk variables in terms of their frequency of occurrence and impact on the project.

[24] Cf. Pietz (2010) and Weber, Schmid, Pietz, & Kaserer (2010) for a discussion on the modelling of energy prices using Autoregressive Conditional Heteroskedasticity (ARCH) and Generalised Autoregressive Conditional Heteroskedasticity (GARCH) time series forecasting models

With regards to the latter, the amount of time that the project is not operational is modelled as a stochastic factor. This is based on measuring the expected service outage, the percentage of the service affected, and its associated cost in resolving the event. This represents the revenue risk of the project.

Unexpected maintenance events of the wind farm that could lead to downtime have been identified as sabotage, machinery breakdown, supply shortage of key equipment or machinery and, broad category for the residual events, grouped under other.

Of these risk variables, those which are considered to be the most prevalent in terms of occurrence is machinery breakdown and the supply shortage of key equipment and machinery – where these events are deemed to occur between 1.4 – 2.4 times per year; and, the residual risk factors as categorised under ‘other’ which are estimated to occur between 4 – 7 times per year. The latter is also given the highest range of values when it comes to defining the revenue impact on the project through the amount of time the wind farm will be non-operational.

Table 8: Unexpected Maintenance Events during Operations

Risk type or event description	**Frequency of occurrence**	**Impact**		
		Expected service outage	**Percentage of service affected**	**Expected cost for resolving (% of scheduled maintenance costs)**
Sabotage	once in 3y - 6y	12h - 1d	up to 10 %	up to 10 %
Machinery breakdown	1,4 - 2,4 per y	1d - 3d	10 - 20 %	10 - 20 %
Supply shortage of key equipment/ machinery	1,4 - 2,4 per y	1d - 3d	10 - 20 %	10 - 20 %
Other	4 - 7 per y	3d - 6d	up to 10 %	10 - 20 %

Source: Development Bank of Southern Africa, 2014

Meanwhile, there are a further six risk drivers that have been identified as major operational events. Unlike the risk events falling under maintenance, a number of these operational risks are influenced by the setting of the host country. For example, strike and labour issues, which are a common theme in South Africa’s business landscape, are considered as a risk factor. It has been estimated to occur between 1.4 – 2.4 times per year, while having a moderate impact on project’s revenue as measured by expected service outage and the percentage of service affected.

A similar country level consideration is grid and network distribution problems. At the time of project development, South Africa’s local power utility was considered to be under maintenance pressures and this had been foreseen as a problem that could lead to a decrease in the amount of power allocated to the grid from the wind farm. Specifically, they are estimated to occur between 1.4 – 2.4 times per year.

The other factors that have been included in the model are software and network errors, health and safety events, key staff unavailability and the supply of key consumables. A summation of these risk variables, including their frequency of occurrence and impact on the project are presented below in Table 8.

Table 9: Major Operational Event Risk Drivers during Operations (Non-Maintenance Related)

Risk type or event description	Frequency of occurrence	Impact		
		Expected service outage	Percentage of service affected	Expected cost for resolving in ZAR
Software/ network errors	1,4 - 2,4 per y	up to 12h	up to 10 %	1M - 10M
Grid/ distribution problems	1,4 - 2,4 per y	12h - 24h	30 - 40 %	1M - 10M
Strike/ labour issues	1,4 - 2,4 per y	2d - 4d	up to 10 %	1M - 10M
Health and safety events	1,4 - 2,4 per y	up to 12h	up to 10 %	1M - 10M
Key staff unavailability	once in 1,2y - 1,4 per y	up to 12h	up to 10 %	1M - 10M
Supply of key consumables	once in 1,2y - 1,4 per y	up to 12h	up to 10 %	1M - 10M

Source: Development Bank of Southern Africa, 2014

After the revenues have been accounted for, the operating costs of the project are added. These costs are treated either as fixed or variable costs.

Machinery and equipment costs, labour and management costs and consulting fees, costs for consumable supplies or services, as well as the hedges and price agreements for these consumables are considered as fixed cost components in the model; that is, they are specified at the beginning of the period and assumed to be constant in the future.

Meanwhile, there is one variable cost component in the model, which is the scheduled maintenance and enhancement costs per period. This is modelled as a percentage (42%) of the period's overall operational costs, per quarter. This percentage value does not vary over the 20-year time horizon of the project.

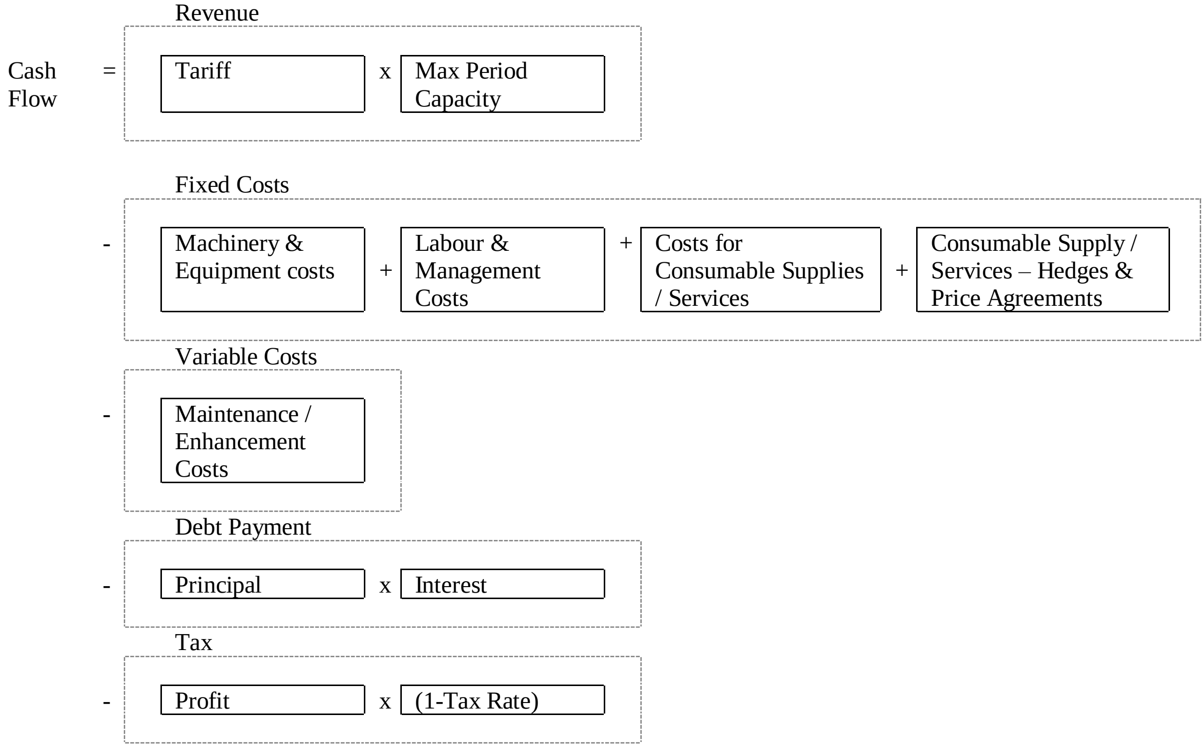
4.3.2. The Computation Component

4.3.2.1. Calculation of the Cash Flows

The relationship between the above identified inputs of the project is specified in the initial part of the computation component. This forms the cash flow equation, which underlies the valuation process.

Figure 6 is a graphic representation of the equation; it illustrates the relationship between the input variables and the effects of the projects financing structure – which have been introduced at this point – on the valuation process. The cash flow equation as defined here is used to determine the base case valuation of the project. This is presented in section 4.1.

Figure 5: Cash Flow Equation



Source: Adapted from Pietz (2010); Development Bank of Southern Africa (2014)

The cash flow equation has five constituent parts, each of which have been demarcated under their respective headings and within outlined boxes. The equation's income segment, labelled revenue, has two constituent parts, specifically the tariff and the maximum period capacity (the amount of electricity generated). The total revenue is calculated as the product of these two factors in each period.

Next, the fixed costs, comprises of the four cost elements that were identified in section 3.3.1. These costs are non-stochastic; their value is determined at the start of the project's lifecycle and are constant thereafter. The aggregate amount of these costs are subtracted from the revenue.

The fourth part of the equation is the second cost component, the variable cost, which is likewise subtracted from the revenue. The variable cost is also a non-stochastic component; it is modelled as 42 percent of the operational costs per period.

The fifth part requires the modelling of the debt payments. Importantly, the case study does not assume an annuity debt repayment profile i.e. level debt service. Instead, the debt is amortised in floating terms, as per the financing parameters of the project presented in table 3. This provision has been accounted for in the cash flow equation, and historical JIBAR rates have been used to determine the floating rate debt portion. The debt is provided to the project in one currency, namely ZAR – implying that no currency forecasting is required to determine future debt payments. [25]

Finally, the sixth part of the cash flow equation models the tax calculation, which is determined by the tax rate set for the country. Specifically, the tax amount payable is the product of the earnings before tax and the tax rate – which is set at 28 percent.

4.3.2.2. Monte Carlo Simulation

After the input parameterisation of the model has been established, the cash flow paths are computed via applying the Monte Carlo simulation technique. The simulations are undertaken concerning the parameters of the distribution variables.

As per section 3.3.1, a total of 14 distribution variables are used in the model to account for uncertainty. Through the random sampling of numbers within these variables, a range of possible outcomes of the cash flows is generated.

[25] CF. Pietz (2010) for the time series modelling of the US Dollar / Euro exchange rate

For example, in determining one cash flow path, a simulation may take into account a strike and labour issues in 2015, grid and distributions problems in 2016, or an adverse climatic occurrence in 2020 – thereby creating a scenario.

Each scenario (a single iteration) determines a point-in-time estimate of cash flows. A cash flow path is determined through the repetition of this process. By combining the cash flow paths, a probability distribution of the cash flows is formed.

The amount of time involved to complete this valuation process is a function of the number of parameters in the model, namely the forecast period, the cash flow distribution and the number of iterations. This means that the process could be completed within a few moments, or take considerably longer – up to a few hours. In the instance of the case study, the model is parameterised for a forecast period of 20 years, with the frequency of cash flow distribution set for a quarterly basis. In order to determine the cash flow paths, 10,000 iterations are run in the simulation.

According to the DBSA, the reason that the model is not parameterised to produce monthly cash flow distributions, is that to a degree the computing power, but especially the computation time, required would be too large considering the model runs off Excel software (Van Biljoen, Rao, & Ngoasheng, 2014).

4.3.3. The Output Component

After running the Monte Carlo simulations, the cash flow paths are combined to form a probability distribution. The measurement of the financial indices are based on this distributions. Two outputs are produced, firstly, the probability distribution of the NPV; and secondly, the coverage ratio, DSCR, to determine the term structure of the PD of the project.

As stated in the methodology section under section 3.4, in order to develop the graphical outputs of the probability distribution of NPV, the simulations will be re-run using the exact same parameterisation of the variables. This is done using @Risk® software (version 6.3.1) developed by Palisade Corporation as the risk analysis tool (Palisade Corporation, 2010).

4.4. Simulation Results and Interpretation

This section provides for two valuations of the case study project. Firstly, the DBSA's estimations of the NPV and DSCR is presented – both of which are based on a deterministic modelling approach. Thereafter, the range of possible NPV values, as well as estimations of default probabilities is presented – these having been obtained through the application of a Monte Carlo simulation to the cash flow streams of the project.

By presenting these two outcomes, it is the objective of this section to showcase the impact on valuation through the application of simulation on the main cash flow drivers.

4.5. Defining the Base Case

The base case is a deterministic financial cash flow model of the case study project. It provides an initial estimate of the project's NPV and DSCR, based on the projected single-value estimates of these variables.

It is again noted here that the base case does not incorporate a quantitative assessment of the underlying project risks associated with the construction and operational parameters. As such, changes in the project's cost and revenue stream due to the realisation of these risk events are not considered in the base case project valuation.

4.5.1. Base Case NPV Analysis

In line with the assumptions of the cost and revenue inputs and their respective estimates detailed in section 3.3.1, the deterministic cash flow model produces a project NPV of ZAR135, 048, 440.88 (DBSA, 2014). Given this outcome, the project would clearly be accepted under the NPV decision rule.

4.5.2. Base Case DSCR Analysis

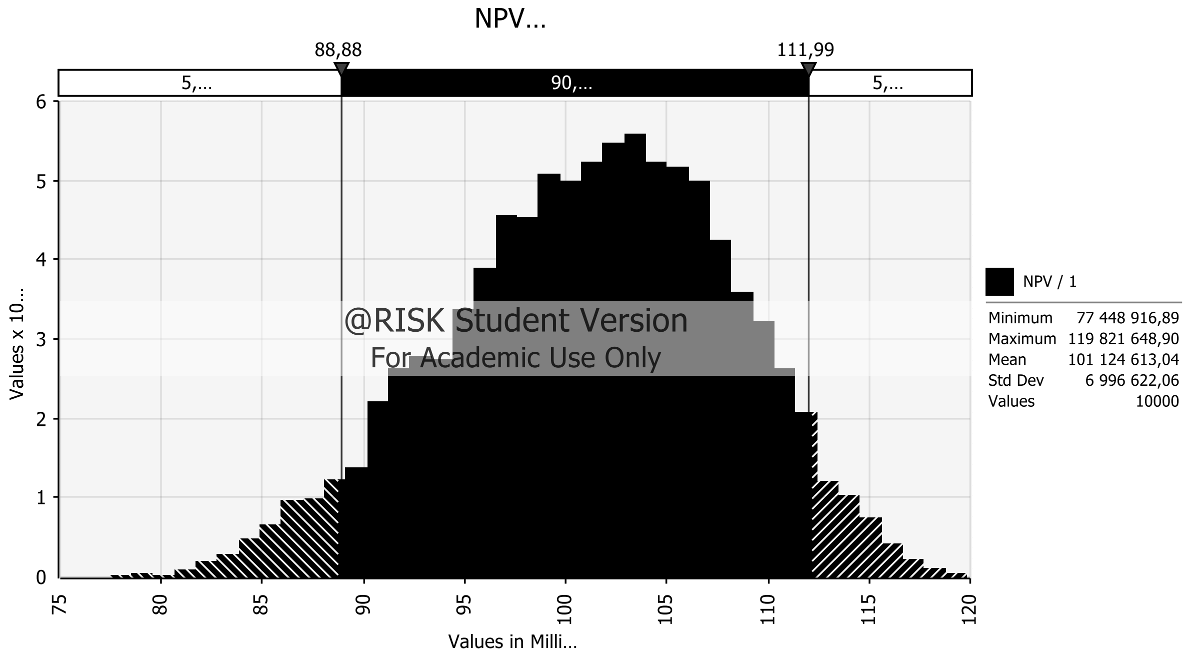
Instead of calculating the base case DSCR for each loan product, senior, junior and mezzanine loans; the aggregate DSCR calculation of the project is used in order to simplify the analysis and to draw comparisons with the estimates of the PD of the project loan.

Given the financial input parameters detailed in section 3.3.1, and the cash inflow component of the cash flow equation, the project has a DSCR of 1.47 (DBSA, 2014). While this ratio indicates that default is unlikely at a given point-in-time, it provides no information as to the likelihood of default in future periods.

4.6. Results of Simulation

After the Monte Carlo simulation procedure is completed, the model output yields a range of possible outcomes of the NPV. Figure 7 below demonstrates that the final valuation of the project is an NPV, which has a 90 percent probability of falling within the range of ZAR 88.88 – 111.99 million.

Figure 6: Case Study Simulation Results



Source: Own Work, based on Development Bank of Southern Africa, 2014

When comparing the results of the simulation to that of the point-estimate NPV calculated in the base case, it is evident that the mean NPV from the simulation is 25.1 percent lower than the NPV calculated in the deterministic model.

This indicates that the NPV of cash flow streams differs under that of the deterministic model, as Monte Carlo simulation is able to recognise the effect of random movement across the simulated variables.

Conversely, the deterministic cash flow model presented in the base case, does not consider this; instead, the model calculates a cash flow based on the expected cost and revenue of a single path.

It could be argued that by not incorporating uncertainty through the risk drivers, a level of optimism bias (or error) is present in the base case calculation, as the capital and operational costs, as well as the production volume are under-estimated and over-estimated, respectively. As a result, this optimistic view has caused error in the forecast of the cash flows and result in an overall higher NPV.

Furthermore, the static model could also not determine the downside risk associated with the project. Beyond the knowledge that the project's NPV has a 90 percent probability of falling in the range specified above; it can be further concluded from the simulation process that there is a 5 percent chance that the NPV of the project will be more than ZAR111.99 million and an equal chance that it will be less than ZAR88.88 million.

It is also possible to determine the possibility that the NPV will be less than zero; that is, that a financial loss will be incurred. Using the simulation outputs, this calculates the percentage of the NPV outcomes within the probability distribution that falls below zero. In terms of the case study, the probability of financial loss is less than 0.1 percent. [26]

This level of statistical analysis is one of the other main advantages of using Monte Carlo simulation; it allows for a realistic assessment of the expected variability and confidence limits of the NPV.

In terms of the second output with which this research concerns itself with, the PD of the project is analysed. Monte Carlo simulation supports the analysis of the PD, as it provides the probability distributions of the cover ratios. This overcomes the primary shortcoming of using cover ratios based on point estimates noted above; that being that they only provide limited information on the borrower's ability to service the debt.

For example, a high DSCR – such as the one noted on the base case (for which a DSCR of 1.42 has been calculated), only indicates that default is unlikely at a given point in time. However, this does not provide information on the PD for future periods. The ability to quantify this information is important from the debt provider's perspective.

[26] Using @Risk software, this is achieved by the function: RiskTarget(Data source, target X value)

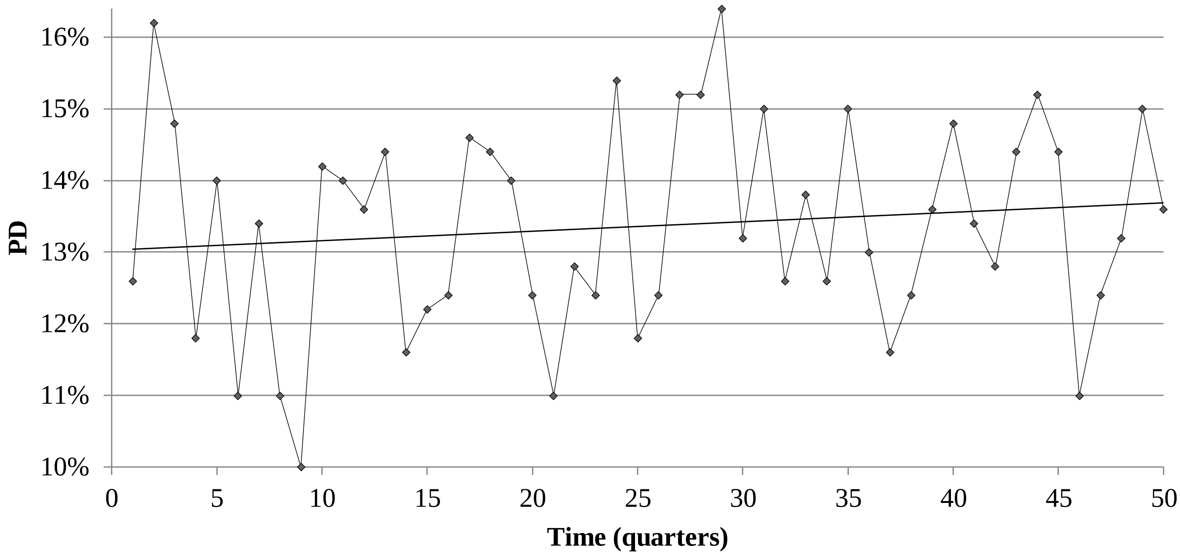
Figure 8 provides estimates of the quarterly PD of the case study project. The graph displays the time since the project started, in quarters, on the x-axis and the cumulative PD of the project on the y-axis. The values are determined for the period extending the financial lifetime of the project (until the loan is repaid).

It is interesting to note that the PD of the project financing is significantly higher in the 1st and 29th quarters in the period – where the values calculated were 16.6 and 16.8 percent, respectively. According to the cash flow output, this is because construction costs have risen (in the first quarter) and the operations are in an area where costs are higher and production has been slightly more affected than in other years (in the 29th quarter). That is to say, the PD is higher in these periods on account of unfavourable risk simulations that have been calculated on account of risk events that have been realised in the construction and operations phase.

Furthermore, it is notable that the PD is significantly volatile, within the range of 10.4 – 16.8 percent. What may explain the volatility of this ex-ante measurement, is the fact that the cash flows in the model are parameterised for a quarterly basis, instead of a longer time period – such as a yearly specification.

This implies that there is a higher probability to observe a string of negative cash flows over several periods – again, attributable to unfavourable risk simulations in these periods. In such an event, it will have the effect of increasing the PD of the project. However, this effect would not necessarily occur if the cash flow distributions were specified for a yearly parameter, as it is more likely that a series of adverse cash flows would be offset by a series of favourable cash flows.

Figure 7: Financial Lifetime PD of the Project



Source: Development Bank of Southern Africa, 2014

When comparing the results of the PD derived in the simulations to that of the DSCR calculated from the deterministic model based on point estimates, it is evident that the latter under values the coverage ratio and thus it doesn't correctly identify the likelihood that the borrower will default.

A summation of these results, as well as the other outputs of interest that have been derived in the respective models, are presented in table 9 for comparative purposes. It is argued that since the deterministic method is unable to explicitly capture and treat evolving project uncertainties, it does not properly evaluate the capital investments presented in the case study.

By accepting this assertion, Table 9 indicates the degree to which the dynamic and probabilistic model, which incorporates risk and uncertainty in outcomes, is superior to the static and deterministic model, because the valuation of the project has a higher degree of accuracy.

Table 10: Results Comparison

Evaluation Method		NPV (million, ZAR)	DSCR of Project	PD of Project
Deterministic (base case)		194.5	1.42	-
Probabilistic	Mean	155.4	-	13.76%
	Standard Deviation	32.6	-	1.505%

Source: Own Work, based on Development Bank of Southern Africa, 2014

4.7. Credit Rating Score

As this paper is grounded in the consideration of the valuation of a large-scale project in an emerging market setting, it is of importance to identify all the risk factors that affect the valuation of such an investment – at least from a financier's perspective.

Acknowledging that the Monte Carlo simulation process detailed in Section 4.3.1 does not consider a number of the contextual risk factors in the process of determining the future cash flows – with particular reference to political risk; the scope of the dissertation has marginally evolved to determine how these elements – which as noted in the literature review as being more prevalent in an emerging market host country environment – are integrated into the valuation of the project.

In practice, this is done by complimenting the PD calculated in the previous section with a qualitative overlay, which determines a credit score – this is the final credit risk metric of the project. [27]

More specifically, a qualitative overlay consists of questions which are framed in relation to the contextual risk factors that the project is confronted with; and, which need to be taken into account in order to determine the credit worthiness of the project. The use of an overlay template offers a structured approach to considering analytical issues, such as those that affected the case study project.

Table 11 presents the qualitative overlay that is used to calculate the credit score of the case study. [28] This comprises of risk factors that can be categorised into eight stand-alone risk categories, namely completion, market, operating, legal, environmental, social, group support and country risk.

The risk categories do not have fixed weights, implying that more weight is attributed to the highest risk which has been identified. Moreover, only one high risk can adversely affect the credit worthiness of the project.

[27] C.f. section 2.3, which covers the relevant academic literature on credit ratings

[28] The complete list of qualitative inputs used to derive this score is presented in appendix 2 of this paper

In terms of the case study investment of the wind farm, the prevailing risk factors were identified as being construction risk, market risk and operating risk, where weightings of 30, 20 and 15 percent were assigned respectively.

With regards to political risk, the weighting from the country risk category is such that it only contributes a marginal amount to the overall score. This comes as the project is located in South Africa, where a relatively stable political and policy environment exists.

However, for the DBSA-financed infrastructure projects which are being developed outside of South Africa, such as in the 14 other countries within the Southern African Development Community (SADC) as well as a number of African countries outside this region – this being in line with the organisation's investment mandate – the score weighting from the political risk would be altered upwards to account for higher political uncertainty (Van Biljoen, Rao, & Ngoasheng, 2014).

The qualitative overlay comprises of approximately 30 questions grouped together in the aforementioned risk categories. Object scoring guidelines are used to classify each of these factors in terms of being 'excellent', 'above average', 'below average', or 'poor'. A favourable answer to any of the identified question, i.e. answering 'above average' allocates a higher score. Logically, it follows that an adverse answer to questions would result in a lower score.

For example, question A1, which pertains to completion risk, is posed to determine how the risk of completing the project has been mitigated in terms of possible cost overruns. The DBSA deemed that this falls into the 'above average' category, thus assigning a score of 74.5 associated with this answer. Justifying this score, the analyst working on the project notes that "the EPC and O&M (operating and maintenance) contractor has received letter of recommendations from some of the leading financial institutions in Europe (BNP Paribas and BPCE Group)" (DBSA, 2014).

Table 11: Qualitative Overlay, Score Calculation

	No.	Question	Score	Weight	Score contribution
A	**Completion Risk**			**30%**	
	A1	How is the risk of completion mitigated in terms of cost?	74,5	33,3%	7,45
	A2	What is the quality of the planning / design of the construction phase?	74,5	33,3%	7,45
	A3	What is the risk of cost overruns in relation to the cost schedule?	74,5	33,3%	7,45
B	**Market Risk**			**20%**	
	B1	How reliable are the estimates of the base case assumptions?	100	50%	10,00
	B2	What is the project feasibility from the independent market survey?	100	50%	10,00
C	**Operating Risk**			**15%**	
	C1	What is the risk of losses of valuable input or output due to technological inefficiency?	74,5	10,0%	1,12
	C2	How high is the risk of an interruption in key supply material (supplier reliability and diversification)?	74,5	2,5%	0,28
	C3	How significant are the commitment and incentive scheme of the management team in the project?	74,5	20,0%	2,24
	C4	What is the quality of the management team?	74,5	30,0%	3,35
	C5	What is the quality of financial accounting?	74,5	17,5%	1,96
	C6	What is the level of key-person risk for the project?	74,5	7,5%	0,84
	C7	Is an international skill-set required for the project success and if so, is it adequately covered?	74,5	7,5%	0,84
	C8	How efficient is the hiring process for the project?	74,5	2,5%	0,28
	C9	What is the quality of the maintenance process?	74,5	2,5%	0,28
D	**Legal Risk**			**13%**	
	D1	What is the possibility of enforcement of legal issues having a negative effect on project progress?	74,5	25,0%	2,33
	D2	What is the situation regarding unresolved regulation issues (clarity of regulatory environment in which the project operates)?	74,5	25,0%	2,33
	D3	What is the risk of misuse of operational revenues instead of loan repayment?	74,5	50,0%	4,66
E	**Environmental Risk**			**5%**	
	E1	What is the exposure of the project operations to environmental conditions (e.g. Weather, topography)?	49,5	40,0%	0,99
	E2	Is there a chance of environmental litigation because of the project?	74,5	40,0%	1,49
	E3	Are there any health or environmental issues that can arise from the project?	74,5	20,0%	0,75
F	**Social Risk**			**3%**	
	F1	How significant are the social issues related to the project sites?	74,5	20,0%	0,37
	F2	How significant is safety and security risk on the project?	74,5	40,0%	0,75
	F3	What is the risk of an adverse change in the regional employment structure?	74,5	40,0%	0,75
G	**Group Support**			**8%**	
	G1	How much stakeholder support (e.g. additional equity injections) during the project can be expected?	74,5	100%	5,59

H					
	Country Risk			**8%**	
	H1	How high is the possibility of inter country regulatory conflict in the project?	100	10,0%	0,75
	H2	How efficient is the supporting infrastructure for the project?	74,5	30,0%	1,68
	H3	What is the extent of government support for the project?	74,5	30,0%	1,68
	H4	What is the chance of political instability that will affect the project?	74,5	10,0%	0,56
	H5	What is the likelihood of government intervention that will adversely affect the project?	74,5	10,0%	0,56
	H6	What is the quality and stability of project relevant regulation?	74,5	10,0%	0,56
		Total score:			79,29

Source: Development Bank of Southern Africa, 2014

Overall, the qualitative assessment carriers a 46 percent weighting when calculating the final PD of the project. In this instance, a score of 79.29 was derived for the project, against which the 46 percent weighting applies (Van Biljoen, Rao, & Ngoasheng, 2014).

Thereafter, the PF is benchmarked to the DBSA master rating scale which was presented earlier in this paper[29]. For the project, the PD translates to MS9 for senior debt, and a slightly riskier MS10 for mezzanine and junior financing. By the numbers, this falls between 0.24 percent (the lower bound) and 0.4 percent (the upper bound) for the senior debt, while the other two debt products falls between 0.4 percent and 0.68 percent. The project debt is thus allocated a BBB rating according the rating scale.

[29] C.f. section 2.5.2 (page 23) for information relating to the organisation's master rating scale

5. RESEARCH CONCLUSIONS

The objective of this dissertation was to determine the applicability of simulation-based valuation techniques for the use in the appraisal of project finance investments located in emerging countries.

In order to establish this, a Monte Carlo simulation based cash flow model was presented of a wind energy farm investment that was developed in South Africa. The model produces three main valuation results, which were used to determine the effects of simulation on a project; namely, NPV distributions, default probability and a credit score of the project debt.

It was illustrated that the model accounts for uncertainty in the valuation through the incorporation of event risk drivers in the construction and operational phase of the project. These risk events were both macro in nature – influenced by the country in which the project is located, South Africa; while others were more specific to the characteristics of a wind farm's development.

In either instance, the simulation had the impact of increasing the cost streams and reducing the revenue streams of the cash flow equation. The effect of this was that the mean NPV of the project was reduced when compared to the output generated from the deterministic model – thereby answering research question 1; simulation has an effect on the NPV of a capital investment in an emerging market. Moreover, this effect was significant, when comparison is done on the two mean outputs.

Beyond the considerations of the NPV, the research question also examined the effects of Monte Carlo simulation on the measurement of ex-ante default probabilities – an aspect which is particularly important from a debt provider's perspective.

Here it was shown that the static model undervalues the DSCR, on account of the cash flows which were over-estimated. In fact, the results from the static model indicated there was no chance for project default given the favourable DSCR that was calculated. Conversely, by taking a probability distribution of the DSCR, it was established that the likelihood of default was close to 17 percent.

This answered the second research question; Monte Carlo simulation has an effect on the default probabilities of a project. Once again, when comparing the two outcomes, the difference is pronounced.

Logically it then follows, is a need to determine what the appropriate method is for the correct valuation of a large-capital investments located in an emerging market. To answer this question, the research looks to the literature which pointed to a number of aspects that were noted regarding the usefulness of Monte Carlo simulation – and which were apparent during the simulation procedure.

Firstly, a model based on simulation produces a range of possible values of the NPV. This is significantly more helpful when assessing projects which are located in emerging markets, given the uncertainty of a number of the input variables used to determine the cash flow.

Further to this, Monte Carlo simulation also supports additional statistical insights into the assessment of NPV. This is one of the primary advantages of using Monte Carlo simulation vis-à-vis a static model. Indeed, analysis along these lines overcomes the concerns raised by Bock & Trück (2011), who suggested that the assessment of NPV and cash flows output values does not provide enough information to substantiate an investment decision of a large-scale project in highly uncertain environments, such as an emerging market.

In terms of the sub-research question, which was an issue of the parameterisation of the model; specifically, if the changing of the interval of cash flow distributions will have an effect on the NPV distributions.

The model presented in this paper specified cash flow distributions on a quarterly basis, and in order for the sub-research question to be tested, a monthly parameterisation was required.

However, it was not possible to change this parameter for two reasons; firstly, the model provided by the DBSA did not allow for such a change, and secondly, an attempt to replicate the case study project based on monthly cash flows would fall short given that it would require additional information and assumptions about the project's revenue and cost components. As a result, this aspect of the research could not be determined through a quantitative study.

Notably, according to an interview with the DBSA, it was established that logically, changing the time interval to a monthly cash flow analysis would have the effect of narrowing the NPV distributions. An explanation for why this might be the case was argued in the results section of this paper, where it was stated that it is more likely to observe a series of unfavourable simulations if more frequent cash flow intervals (such as quarterly intervals) were used.

6. RECOMMENDATIONS FOR FUTURE RESEARCH

Given the results of this study, there are a number of avenues for future research within the area of project finance valuation to now be further explored – all of which would represent progressions of this paper.

Chief amongst these would be to apply the country-related risk event drivers, which were used in the Monte Carlo simulation to other projects. It would be especially insightful to consider an ex-post valuations of such projects, in order to determine how accurate the risk drivers were in moderating the NPV measurement. Project finance investments in other industries, such as mining could, for example, be used to examine the effects of the distribution variables and their effects on the results.

Beyond this, given that much of the research being undertaken in the field of valuations is centred on the real options analysis method; it would be interesting to see the valuation results derived by using this technique in a study. Moreover, the real options analysis method could be used to value the case study presented in this paper.

With potential areas for future research having been established, it is concluded that this dissertation has provided readers with a greater knowledge of the nuances of valuing project finance investments in emerging markets. In particular, the foundation established in this study should be considered as beneficial to financiers in their forecasting of cash flows and the resultant valuation of large-scale infrastructure investments in markets characterised by risk and uncertainty.

Indeed, it is hoped that this knowledge will further contribute serve to bridge the infrastructure gap, both in sub-Saharan Africa and other emerging markets.

REFERENCES

Andrukonis, D. (2013). Pitfalls in Conventional Earnings-Based DSCR Measures. *RMA*, 16-36.

Ansar, A. (2011). Project Finance in Emerging Markets. In *The Principles of Project Finance* (pp. 287-299). Gower Publishing.

Bailey, W., Couët, B., & Lamb, F. R. (2000). Taking a Calculated Risk. *Oilfield Review, 3*(12), 20-35.

Baker, K. R., & Powell, S. G. (2004). *The Art of Modeling with Spreadsheets: Management Science, Spreadsheet Engineering, and Modeling Craft* (1st ed.). Hoboken: John Wiley & Sons.

BCBS. (2005). *Studies on the validation of Internal Rating Systems.* Working Paper No. 14, BIS.

Bennett, J., & Ormerod, R. N. (1984). Simulation applied to construction objects. *Construction, Management and Economics*, *2*(3), 225-263.

Bock, K., & Trück, S. (2011). Assessing Uncertainty and Risk in Public Sector Investment Projects . *Journal of Technology and Investment, 2*(1), 105-123.

Brealey, R. A., Myers, S. C., & Allen, F. (2006). *Principles of corporate finance* (8th ed.). New York: McGraw-Hill/Irwin.

Cheah, Y., & Garvin, M. (2009). Application of Real Options in PPP Infrastructure Projects: Opportunities and Challenges. In A. Akintoye, & M. Beck (Eds.), *Policy, Finance & Management for Public-Private Partnerships.* Oxford: Wiley-Blackwell.

Commer, B. (1996). *Project Finance Teaching Note.* Retrieved September 5, 2014, from http://finance.wharton.upenn.edu/~bodnarg/ml/projfinance.pdf

Copeland, T., Koller, T., & Murrin, J. (2000). *Valuation: Measuring and Managing the Value of Companies* (3rd ed.). New York: Wiley .

Damodaran, A. (2006). *Stern School of Business at New York University*. Retrieved April 2015, from http://people.stern.nyu.edu/adamodar/pdfiles/valrisk/ch6.pdf

DBSA. (2014). Project Finance Valuation Model: Wind Energy Investment.

Eberhard, A., Kolker, J., & Leigland, J. (2014). *South Africa's Renewable Energy IPP Procurement Program: Success Factors and Lessons.* Washington DC: World Bank.

Esty, B. (1999). Improved Techniques for Valuing Large-Scale Projects. *The Journal of Project Finance*, *5*(1), 9-25.

Esty, B. C., Chavich, C., & Sesia, A. (2014). An Overview of Project Finance and Infrastructure Finance - 2014 Update. *Harvard Business School Case Collection*.

Esty, B., & Seisa, A. (2007). Overview of project finance and infrastructure finance. *Harvard Business School Cases*.

European Investment Bank. (2010). *Guide to Financing Projects from European Technology Platforms.* Retrieved May 5th, 2015, from http://www.eib.org/attachments/thematic/european_technology_platforms_en.pdf

Fabozzi, F. J. (2008). *Handbook of Finance, Financial Markets and Instruments* (1st ed.). Hoboken: Wiley.

Fight, A. (2006). *Introduction to Project Finance (Essential Capital Markets Series)* (1st ed.). Oxford: Butterworth-Heinemann.

Finnerty, J. (1996). *Asset-Based Financial Engineering* (2nd ed.). Hoboken: John Wiley & Sons.

García-Cascales, M., Sánchez-Lozano, J., Masegosa, A., & Cruz-Corona, C. (2014). *Soft Computing Applications for Renewable Energy and Energy Efficiency* (1st ed.). Hershey: IGI Global.

Gardner, D., & Wright, J. (2010). Project Finance. *Encyclopedia Of Debt Finance, Euromoney Institutional Investor*.

Gatti, S. (2013). *Project Finance in Theory and Practice* (2nd ed.). London: Elsevier.

GIB Foundation . (2014). *GIB Foundation.* Retrieved April 15, 2015, from http://www.gib-foundation.org/content/uploads/2014/05/Scoping-Study-for-the-Early-Phase-Project-Preparation-Phase_.pdf

Gimpel, M. D. (2010). *The Applicability of Conventional Valuation Techniques under the Economic Conditions of Developing Countries.* Copenhagen: Copenhagen Business School. Retrieved December 16, 2013, from http://studenttheses.cbs.dk/bitstream/handle/10417/1303/moritz_david_gimpel.pdf?sequence=1

Haley, G. (2013). A New Phase in Global Project Finance. In *Africa Infrastructure Investment Report* (pp. 64-66). London: Commonwealth Business Communications Ltd. Retrieved from http://www.cbcglobal.org/images/uploads/docs/The_CBC_Africa_Infrastructure_Investment_Report_2013.pdf

Henisz, W. J., & Zelner, B. A. (2010, April). The Hidden Risks in Emerging Markets. *Harvard Business Review.*

Hertz, D. B. (1964, January/February). Risk Analysis in Capital Investment. *Harvard Business Review*, pp. 99-196.

Hillier, F. S. (1963). The Derivation of Probabilistic Information for the Evaluation of Risky Investments. *Management Science, 9*(3), 443-457.

Hoffman, S. (2001). *The Law and Business of International Project Finance* (2nd ed.). The Hague: Transnational Publishers.

IMF. (2015). *IMF World Economic Outlook* . Retrieved 2015, from http://www.imf.org/external/pubs/ft/weo/2015/01/weodata/index.aspx

International Project Finance Association. (2015). *About: International Project Finance Association*. Retrieved 2015, from http://www.ipfa.org/about.shtml

Joppe, M. (2000). *The Research Process.* Retrieved from http://www.ryerson.ca/~mjoppe/rp.htm

Kaka, A. (1996). Towards more flexible and accurate cash flow forecasting. *Construction Management and Economics, 14*(1), 256-267.

Kebede, E., Kagoshi, J., & Jolly, C. (2010). Energy consumption and economic development in Sub-Sahara Africa. *Energy Economics, 32*, 532-537.

Kelliher, C. F., & Mahoney, L. S. (2000). Using Monte Carlo Simulation to Improve Long-Term Investment Decisions. *The Appraisal Journal, 68*(1), 44-56.

Kleimeier, S., & Megginson, W. L. (2001). An Empirical Analysis of Limited Recourse Project Finance. *University of Oklahoma, Michel F. Price College of Business Working Paper Series*.

Lu, Y.-., Wu, S., Chen, D.H., & Lin, Y.Y. (2000). BOT Projects in Taiwan: Financial Modeling Risk, Term Structure of Net Cash Flows, and Project at Risk Analysis. *Journal of Project Finance, 5*(4), 53.

McKinsey Global Institute. (2013, January). *Infrastructure Productivity: How to save $1 trillion a year.* Retrieved September 2014, from file:///C:/Users/John/Downloads/MGI_Infrastructure_Full_report_Jan2013.pdf

Metropolis, N., & Ulam, S. (1949). The Monte Carlo Method. *Journal of the American Statistical Association, 44*(247), 335-341.

Mohamed, S., & McCowan, A. (1999). Modelling project investment decision under uncertainty using possibility theory. *International Journal of Project Management, 1*(19), 231-241.

Mooilanen, T., & Martin, C. (1996). *Financial Evaluation of Environmental Investments* (1st ed.). Warwickshire: Institution of Chemical Engineers.

Mun, J. (2002). *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions* (2nd ed.). New York: Wiley Finance.

OECD. (2007). *Infrastructure to 2030: Volume 2*. Retrieved September 2014, from http://www.oecd.org/futures/infrastructureto2030/40953164.pdf

Ozdemir, B., & Miu, P. (2009). *Basel II Implementation* (1st ed.). New York: McGraw-Hill.

Palisade Corporation. (2010). *@Risk User's Guide: Risk Analysis and Simulation Add-In for Microsoft® Excel*. New York.

Pietz, M. (2010, November). *Simulation-based Valuation of Project Finance Investments – Crucial Aspects of Power Plant Projects*. Retrieved July 2014, from https://mediatum.ub.tum.de/doc/998193/998193.pdf

Samis, M., & Davis, G. A. (2014). Using Monte Carlo simulation with DCF and real options risk pricing techniques to analyse a mine financing proposal. *International Journal of Financial Engineering and Risk Management, 1*(3), 265-281.

Sasraku, F. (2013). Risks in Gas-Powered Project Financing. In K. Appiah-Adu (Ed.), *Governance of the Petroleum Sector in an Emerging Developing Economy* (pp. 65-78). London: Gower Publishing.

Savvides, S. (1994). Risk Analysis in Investment Appraisal. *Project Appraisal Journal, 9*(1), 3-18.

Smith. (2010). *International Project Finance Manual* (1st ed.). Dundee: Centre for Energy, Petroleum and Mineral Law and Policy.

Smith, R. C., & Walter, I. (2003). *Global Banking* (2nd ed.). New York: Oxford University Press.

Sy, A. (2013, October 9). *Financing Africa's Infrastructure Gap.* Retrieved from Brookings Institute: http://www.brookings.edu/blogs/up-front/posts/2013/10/09-financing-africa-infrastructure-gap-sy

Tamaki, R. (2013). Financing Africa's Infrastructure Deficit through Cooperation. In *Africa Investment Report* (pp. 51 - 55). London: Commonwealth Business Communications Limited.

The European Wind Energy Association. (2013, November). *Financing offshore wind farms.* Retrieved from EWEA : http://www.ewea.org/fileadmin/files/library/publications/reports/Financing_Offshore_Wind_Farms.pdf

UNEP. (2015). *Publications: UNEP.* Retrieved June 22, 2015, from http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2015

Van Biljoen, C., Rao, A., & Ngoasheng, H. (2014, June 12). DBSA Project Finance Rating Model Demonstration. (J. F. de Villiers, Interviewer)

Wagle, B. (1967). A Statistical Analysis of Risk in Capital Investment Projects. *Operational Research Society, 18*(1), 13-33.

Weber, F., Schmid, T., Pietz, M., & Kaserer, C. (2010). *Simulation-Based Valuation of Project Finance - Does Model Complexity Really Matter?* Munich: Center for Entrepreneurial and Financial Studies (CEFS). Retrieved December, from City of Johannesburg Web site: http://www.joburg.org.za/index.php?option=com_content&task=view&id=4109&Itemid=198

World Bank. (2010). *Africa's Infrastructure: A Time for Transformation.* Retrieved September 23, 2014, from http://siteresources.worldbank.org/INTAFRICA/Resources/aicd_overview_english_no-embargo.pdf

World Bank. (2013). *Fact Sheet: Infrastructure in Sub-Saharan Africa.* Retrieved from World Bank:

http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/0,,contentMDK:21951811~pagePK:146736~piPK:146830~theSitePK:258644,00.html

Yescombe, E. R. (2002). *Principles of Project Finance* (1st ed.). Waltham: Academic Press.

APPENDIX 1

Formula 1: Standard DCF Model

$$NPV = I_O + \sum_{t=1}^{\infty} \frac{FCF_t}{(1+r)t}$$

Source: Brealey, et al. (2006): 36

Formula 2: Debt Service Coverage Ratio

$$DSCR_t = \frac{CF_t}{DRA_t}$$

Where;

CF_t = the operative cash flow in period t;

DRA_t = the debt repayment amount, i.e. interest + principal, in period t.

Source: Andrukonis (2013): 17

APPENDIX 2

Table 12: Completion Risk

Turn-Key contract	How is the risk of completion mitigated in terms of cost?	Fixed price turn-key contract and contractor has excellent reputation and track record	Fixed price turn-key contract and contractor has good reputation and track record	Fixed price turn-key contract with weak contractor	No fixed price contract or poor contractor quality
Design/Planning	What is the quality of the planning / design of the construction phase?	Excellent quality by proven and experienced design experts in the sector	Good quality by proven and experienced experts in the sector	Good quality by experts with no track record in the sector	Poor quality by experts with no track record in the sector
Cost estimate	What is the risk of cost overruns in relation to the cost schedule?	Highly reliable estimates including a realistic buffer	Reliable estimates based on previous experience and market intelligence	Less reliable estimates based on limited experience	Unreliable estimates based only on expert judgment

Source: Development Bank of Southern Africa, 2014

Table 13: Market Risk

Demand	How reliable are the estimates of the base case assumptions?	Very low expected volatility of the estimates	Moderate expected volatility of the estimates	High expected volatility of the estimates	No reliable information available
Feasibility	What is the project feasibility from the independent market survey?	Highly feasible in terms of market growth, competition and demand	Feasible with a few resolvable issues	Feasible to a degree but with a number of potential obstacles	No survey has been done so far/unfeasible

Source: Development Bank of Southern Africa, 2014

Table 14: Operating Risk

Technology	What is the risk of losses of valuable input or output due to technological inefficiency?	Most recent technology used	Recent technology with few losses	Old technology with some losses	Old technology with considerable losses
Supply	How high is the risk of an interruption in key supply material (supplier reliability and diversification)?	No risk	Some risk but not a threat to the progress of the project	Significant risk with rather low reliability	Extremely unreliable and no chance of avoiding the risk
Management	How significant are the commitment and incentive scheme of the management team in the project?	Significant commitment combined with high incentives	Average commitment combined with high incentives	Adequate commitment with low incentives	Low commitment and low incentives
Management	What is the quality of the management team?	Excellent with a long track record in similar projects	Good with a short track record in similar projects	Below average with only a track record in smaller size projects	Poor management quality and/or no track record in similar projects
Accounting	What is the quality of financial accounting?	Excellent financial accounting staff or audited financials	Good accounting staff with sufficient experience, financials available but unaudited	Average accounting staff and practices	Poor accounting or non-audited financial statement

Key-person risk	What is the level of key-person risk for the project?	No key-person risk	Project success depends on small group of key-persons (6-10)	Project success depends on a very small group of key-persons (3-5)	Project success depends on a single person (1-2)
Labour	Is an international skill-set required for the project success and if so, is it adequately covered?	No requirement or adequately covered	Required and covered to a satisfactory degree	Required and only scarcely covered	Required and no coverage
Labour	How efficient is the hiring process for the project?	Extremely effective, having resulted in excellent staffing	Hiring process is good but can be improved for better staffing	The hiring process is not effective and requires some changes in the policy of hiring	The hiring process is totally ineffective, requires major changes on every level
Maintenance	What is the quality of the maintenance process?	Fully adequate maintenance process implemented	Reasonably adequately maintenance process with areas for improvement	Incomplete maintenance process which is poorly implemented	No effective maintenance process in place

Source: Development Bank of Southern Africa, 2014

Table 15: Legal Risk

Enforceability	What is the possibility of enforcement of legal issues having a negative effect on project progress?	None	Some legal issues may arise but they can be resolved easily	Many legal issues with a small chance of resolution	High number of legal issues but no chance of resolution
Regulation	What is the situation regarding unresolved regulation issues (clarity of regulatory environment in which the project operates)?	No unresolved issues	Some unresolved issues with no significant impact on the project	Many unresolved issues that may be solved with proper planning	Many unresolved issues cannot be solved at all
Corporate Governance	What is the risk of misuse of operational revenues instead of loan repayment?	None	Some chance of misuse but likely to have no significant impact on the project	Chances of misuse of funds are there and would require proper planning	Very risky and misuse of funds highly probable

Source: Development Bank of Southern Africa, 2014

Table 16: Environmental Risk

Weather	What is the exposure of the project operations to environmental conditions (e.g. Weather, topography)?	Environmental conditions are unlikely to affect project operations or risk is fully mitigated (e.g. Insurance)	Environmental conditions may affect project operations but exposure is mostly mitigated (e.g. Insurance)	Environmental conditions may affect project operations with restricted mitigation	Project is highly exposed to and affected by adverse environmental conditions
Litigation	Is there a chance of environmental litigation because of the project?	No chance of litigation or fully mitigated	Minor chance of environmental litigation	Environmental litigation is likely	Unavoidable environmental damage, will probably result in extreme opposition or lawsuits

Health Hazards	Are there any health or environmental issues that can arise from the project?	None or full coverage	Some but likely to be fully covered	Reasonably high with limited coverage	High health hazards and insufficient or no coverage

Source: Development Bank of Southern Africa, 2014

Table 17: Social Risk

Project site	How significant are the social issues related to the project sites?	Extremely supportive community	Mostly supportive with high possibility of resolving conflict	A lot of opposition with some possibility of resolution	Extreme opposition, no chance of resolving conflict without litigation
Safety and Security	How significant is safety and security risk on the project?	Not at all	Minor safety and security issues with high chance of mitigation	Major safety and security issues with little chance of mitigation	Extremely dangerous safety and security issues with no chance of mitigation
Employment	What is the risk of an adverse change in the regional employment structure?	The project will create many new jobs	The project will create some employment opportunity but not significant	Some unemployment may result due to the project but not significant	The project is a major cause of unemployment with no possibile solution

Source: Development Bank of Southern Africa, 2014

Table 18: Group Support

Sponsor	How much stakeholder support (e.g. additional equity injections) during the project can be expected?	The sponsor has a strategic interest and a considerable equity stake in the project	The sponsor has a strong interest and a minor equity stake in the project	The sponsor has limited interest in the project and/or a minor equity stake	The sponsor has no interest and no equity stake in the project

Source: Development Bank of Southern Africa, 2014

Table 19: Country Risk

Inter-country regulation	How high is the possibility of inter-country regulatory conflict in the project?	None	Very little with high possibility of resolution	Some chance but considerable effort has to be made to avoid conflict or litigation	High probability of inter-country regulatory conflict
Infrastructure	How efficient is the supporting infrastructure for the project?	Comprehensive and reliable infrastructure	Reliable but incomplete infrastructure	Low infrastructure availability and would require significant additional infrastructure installation	No infrastructure available
Political support	What is the extent of government support for the project?	Top-level government support, strategic interest in the project success	Senior administration level government support	Moderate government support	No government support
Political stability	What is the chance of political instability that will affect the project?	None	Some chance but will not cause any delay in the project	Some chance but considerable effort has to be made to avoid political risk	Extremely risky, high likelihood of government intervention resulting in delay or completion risk (condition precedent of political risk insurance in place)

Government intervention	What is the likelihood of government intervention that will adversely affect the project?	Very unlikely, evidenced by a lack of precedents	Government intervention may occur but effects are uncertain	Government intervention with potentially adverse effects likely	Government intervention with adverse effects imminent
Regulation	What is the quality and stability of project relevant regulation?	High quality and stability of regulation	High quality but some possibility of regulation changes	Low quality but high stability of regulation	Low quality of regulation and high probability of regulation changes that will adversely affect the project

Source: Development Bank of Southern Africa, 2014